Initial Communications Operating Concept and Requirements for the Future Radio System

18 January 2005

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1 INTRODUCTION

1.1   Background

The growth in aviation traffic has resulted in enormous pressure on the ability of existing spectrum resources to satisfy communication requirements. The very high frequency (VHF) spectrum is already congested and will be the significant limiting factor in Air Traffic Management (ATM) capacity by 2015 unless additional air/ground communication resources are made available to supplement the existing systems. In the past, the increased need for frequency channels in the VHF band has been met by reducing the channel bandwidth and/or reallocation. The most recent example of channel bandwidth reduction is the European mandate to subdivide the 25-kilohertz (kHz) channel into three 8.33-kHz channels to expand the number of available Air Traffic Control (ATC) voice channels. The limited number of available voice channels and the expected growth in the number of new services requiring higher bandwidth data channels are major factors driving the need for new communication capabilities.

To address this issue, EUROCONTROL and the FAA have initiated a joint activity under Action Plan (AP) 17 to identify potential future communications technologies to meet safety and regularity of flight communications requirements, i.e., those supporting Air Traffic Services (ATS) and Aeronautical Operational Control (AOC).

The Future Communications Study (FCS) addresses the need for globally harmonised planning of future aviation communications. The two primary drivers for a Future Radio System (FRS) are: 1) the need for increased capacity, and 2) the need for a consistent global solution to support the goal of a seamless air traffic management system.

A key product of the FCS is the recommendation of the most appropriate technologies and implementation means to supplement the existing voice and data communications systems to meet the requirements—starting in 2015 with a lifetime of at least 15 years—until 2030.   The new technologies will be required to support voice and data communications; both air/ground and air/air, broadcast, and addressable. The FCS work plan identifies communications operating concepts and requirements as a prerequisite, critical path element in the process of making such a recommendation.

While analog voice communications capabilities remain central to the provision of ATM services, they are progressively being supplemented by digital communications services in the future. Data communications allow increased levels of information throughput and higher levels of security, reliability, and automation. Thus, any proposed new radio system must be capable of supporting these modes of operation.

Any new system must be capable of supporting not only current, but also emerging operational concepts. In other words the new system should not simply strive to deliver

"more of the same," but must be capable of supporting new and better ways of working that generate higher levels of efficiency, safety, and economy (e.g., Free Route and Free Flight Airspace concepts).

1.2   Purpose

The purpose of this document—the Initial Communications Operating Concepts and Requirements (ICOCR)—is to identify concepts and trends supporting the selection of the next generation communications system. The ICOCR is identified as Task 2.1 of the AP 17 work plan. The need to coordinate and develop consensus on the essential themes in the work plan will require dissemination and coordination of this document among the wider civil aviation and industry communities.

The operational requirements are drawn from the ATM and AOC operating concepts expected to be implemented in the highest density airspace regions of the world to achieve the required capacity and safety. Lower density regions of the world have also been considered but the communication requirements for those regions are likely to be met beyond 2015.   However, these areas would benefit from use of the new communication technology that will result from global carriage of the equipment by airspace users from other regions.

The FRS operational requirements have been derived from the ICAO Global ATM Operating Concept [Ref 1], the IATA ATM Roadmap [Ref 11] supplemented by information in regional implementation documents such as those from the FAA and EUROCONTROL concept and strategy documents. See Section 1.7.

1.3   Scope

This document is the initial description of the Communications Operating Concepts and Requirements. The ICOCR includes aspects and trends that are well understood and agreed, as well as those that will require further development. It has been produced to encourage comment and contributions from all regions of the world and a range of industry stakeholders to help complete a final version of the document, which will be known as the Final Communications Operating Concepts and Requirements (FCOCR).

The scope of the ICOCR is limited to analyzing trends and operational concepts as part of the FCS needs, and by the fact that both government and industry are in the formative stages of determining many of the underlying future concepts. While not meant to be a complete representation of the future global airspace operating concepts, this document may provide useful input in the ongoing effort to define them.

1.4   Definition and Approach

This document identifies the communications trends and operational concepts of the future ATM and AOC services.

The purpose of the AP 17 study is to recommend the technologies for the airborne and ground radios. This document, as part of the AP17 activities, defines the requirements that the new technology must meet. In this document the term FRS[1] is used to refer to the physical implementation of a communication system that meets these requirements. The scope of the FRS is illustrated in Figure 1-1.
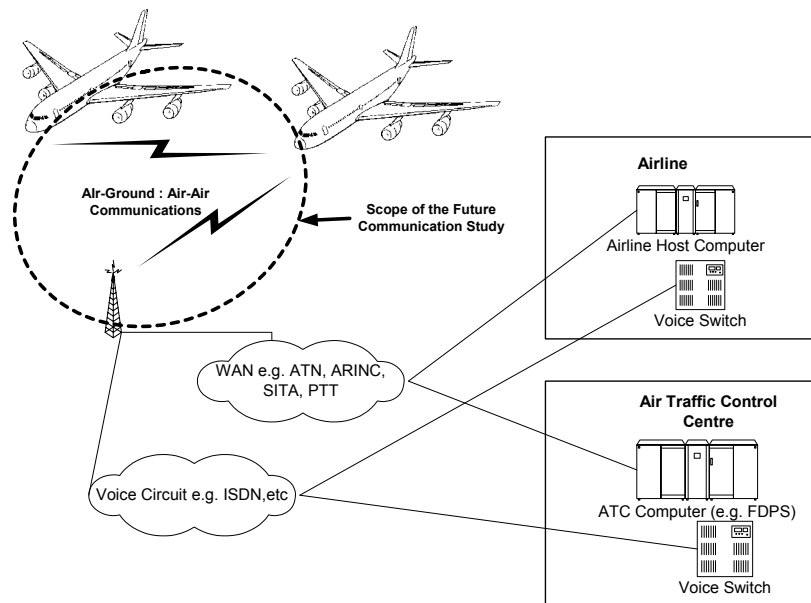
Figure 1-1. The Scope of the FRS

The performance requirements for the FRS are derived from the voice and data service requirements as a starting point and tuned to the scope of the FRS. In a similar fashion, the requirements of AOC voice and data services are interpreted to the FRS scope.

The supporting ATM environment will continue to consist of ground Human Machine Interfaces (HMIs); voice switches; Flight Data Processing Systems (the Automation System); ground communications systems, routers, networks, ground and airborne radios, and communication end systems (e.g., airborne Communications Management Units (CMUs) and ground Data Link Application Processors). These components, combined in an end-to-end chain must meet the required performance and safety for voice and data applications.

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[1] The singular reference to technology is used but the FRS may be a combination of technologies.

1.5   Constraints

1.5.1 Regulatory Constraints

The implementation of the future radio system will have to be undertaken in the context of the regulatory environment where it is developed and operated. Although it is likely that regional regulatory bodies (e.g., FAA and EASA) will be consulted and their requirements met, it has to be recognized that the system must be able to operate globally.

Regulations can have a direct impact on stakeholders. They have an interest in ensuring that regulations provide for a safe environment, are applied fairly, and are not unreasonably burdensome. Examples of industry stakeholders include airlines, general aviation, military, AOC service providers, industry associations (e.g., AEEC, IATA), labor unions, and the flying public.

1.5.2 Spectrum Constraints

The FRS solution must consider the following spectrum constraints.

- Spectrum Assignment/Allocation
- Spectrum Availability
- Spectrum Capacity
- Radio Frequency Interference
- Security and Access Considerations
- Propagation and Coverage Characteristics
- Transition and Implementation

As this document identifies the need for additional communication capacity and how this will evolve, it should help those developing and justifying the requirements for additional spectrum in forums such as the World Radio communication Conference (WRC) the next meeting of which will take place in 2007.

1.6   Document Organization

This document is organized as follows:

- **Section 1 (Introduction)**: This section includes background, document purpose, and FRS constraints. It also describes the document organization.
- **Section 2 (Operational Concepts for Communications)**: This section discusses operational trends and presents real-world, "day in the life" scenarios to describe the anticipated operational concepts.

- **Section 3 (Operational Services)**: This section describes the operational services that are referenced in the Section 2 scenarios.

- **Section 4 (Aircraft and Air Traffic Characteristics)**: This section describes aspects of the environment that would affect, or help determine appropriate provision of the communications services.

- **Section 5 (Operational Security Trends)**: This section outlines high level security requirements.

- **Section 6 (Initial Operational Performance Requirements)**: This section describes communication performance requirements.

- **Section 7 (Communication Loading Analysis)**: This presents a detailed communication system loading analysis based on anticipated message sizes, message frequencies, initial performance requirements and estimated aircraft densities.

- **Section 8 (Summary)**

- **Appendix A (Acronyms and Abbreviations)**

- **Appendix B (STATFOR and SAAM Overview)**: An overview of the EUROCONTROL STATFOR Service and SAAM tool.

Since Section 2 includes references to operational services that are described later in Section 3, it may be useful for readers to first review the services therein. The reader should also note that this document makes extensive use of acronyms. All acronyms and abbreviations are defined in Appendix A.

1.7 Document References

The primary reference documents used in this ICOCR include:

1 ICAO Global ATM Operational Concept

2 Safety and Performance Requirements Standard for Air Traffic Data Link Services in Continental Airspace – RTCA DO-290/EUROCAE ED-120

3 EUROCONTROL Operational Requirements for Air/Ground Cooperative Air Traffic Services – AGC ORD-01

4 Next Generation Air/Ground Communications (NEXCOM) – RTCA DO-284

5 Roadmap for the Implementation of Data Link Services in European Air Traffic Management (ATM: Non ATS Applications) – European Commission

7 Minimum Aviation System performance Standards for Automatic Dependent Surveillance – Broadcast – RTCA DO-242A

8 Joint Planning & Development Office: End State Description for the Next Generation Air Transportation System, July 2004

9   RTCA National Airspace System Concept of Operations and Vision for the Future of Aviation

10 EUROCONTROL ATM Operating Concept Volume 1, Concept of Operations, Year 2011

11 IATA - ATM Implementation Roadmap – Short and Medium Term – Release Version 1.0 – 15th October 2004

12 EUROCONTROL Air/ground data volumes in Europe – version 0.B – July 2000

2 OPERATIONAL CONCEPTS FOR COMMUNICATIONS

This section describes the operational concepts at the start and end of the period considered in the ICOCR. For the years 2015 and 2030 the concept of operation is described and that is followed by a typical scenario demonstrating how voice and data services are used to support that concept.

Note: The scenarios use the terms Planning Controller and Executive Controller. These terms come from ICAO terminology for controller roles and typically represent a pair of controllers working a sector. Locally, these controllers may be referred to by various names, e.g., R-Side or Radar for Executive Controller and D-Side, Data or Coordinator for Planning Controller.

2.1 Concept Trend for 2015

To support the anticipated level of aviation traffic, all ATM stakeholders (e.g., commercial aviation general aviation, military users, neighboring Air Navigation Service Providers (ANSPs), regulators, airport operators and other governmental entities) must work together in a collaborative manner on planning and executing their aviation operations. All stakeholders may participate in, and benefit from, the advantages of using a wide pool of information. As part of this pool of information, the network operations planning process aims to maintain a continuous balance between demand and capacity, and to identify system constraints. Stakeholders have access to the planning process through a common network; they are able to retrieve information to be used for their tailored purposes or make a query to identify possible constraints, and, in a collaborative manner, use the information to negotiate and develop consensus on possible opportunities to mitigate the constraints.

The ATM system is continuously evolving. The focus of development and change has been the planning process, where communication and information exchange among ATM stakeholders have become increasingly more important. Decision making processes have become more collaborative as common situational awareness among the ATM stakeholders has developed. The roles and responsibilities of the ATM stakeholders are evolving from controlling to managing traffic. The paradigm change from "management by intervention" to "management by planning and intervention by exception" is beginning to form in the ATM environment in 2015.

The most significant evolution completed in this period is flight planning through the implementation of a seamless layered planning process. Basic layered planning existed earlier, but by 2015 it has started to evolve into a continuous planning process. In 2015 the layered planning process generally achieves an agreed and stable demand and capacity balance. This is accomplished through demand and capacity determination, active demand and capacity management, and re-planning for optimization. These tasks

continue across all layers of planning and are not restrained by the time constraints of the individual layer.

The layered planning process will not be described in detail as the focus of this document is on the phases that directly impact the demand on the digital aeronautical communication system (air/ground and air/air communications). Nevertheless, application of the layered planning process will generate the following benefits:

- An improved picture of the predicted traffic situation enabling all ATM stakeholders to analyze and develop their business cases.

- The active involvement of all ATM stakeholders in the decision-making process also supporting and facilitating the use of company planning and company decision support tools.

- The central analysis and solution of network effects within a collaborative decision making process encompassing the concerned ATM stakeholders.

- Decision making by informed ATM stakeholders.

- Communication of real-time events enabling ATM stakeholders to take advantage of changing conditions in real time, thus helping them to achieve their preferences.

The Planning Controller represents the lowest planning level within the layered planning process. Planning Controller's primary task is to plan and establish a conflict free and efficient traffic flow within his area of responsibility. Because of his/her extended geographical and time-related planning horizon, he/she is able to act earlier on expected complexity and conflicts and look for efficient solutions. Furthermore, he/she is able to react more efficiently and flexibly to user requests, such as direct routings, prioritization of individual flights, or special support for on-time arrivals.

A gradual shift in emphasis from an Air Traffic Control (ATC) environment defined by tactical interventions, towards an operating environment based on reliable planning, is beginning. As a consequence, the role of controllers is evolving into a more monitoring and managerial role in certain areas. Examples of this change are seen in the beginning steps of pre-negotiated operations, where the flight crew executes a previously agreed trajectory contract. However, the controller retains the responsibility for separation, or sequencing and merging operations where responsibility (e.g., spacing) is delegated to the flight crew for a specific procedure of limited duration. Consequently, the flight crew's role has begun to change and now includes assumption of these responsibilities previously residing with the controller. All this is supported by new or enhanced functions of the ATM system encompassing air and ground applications.

Operational changes are also being implemented for the management of ground movements. They are optimized to provide maximum use of the ground infrastructure, even in adverse weather conditions, by using new ATM system capabilities. The airspace structure is beginning dynamic adjustment of control sector boundaries according to demand allowing for limited implementation of user preferred trajectories.

All of the changes identified above, technical and operational, will have an impact on the business models of ATM stakeholders. The ATM stakeholders must cope with changing requirements on human skills, new and harmonized operational procedures that cross ATM stakeholder business boundaries, changing requirements on their systems, and newly implemented rules and regulations catering, for example, to environmental issues.

2.2   Scenario in 2015

2.2.1   Communication Allocation between Voice and Data

The assumptions of operational use among voice and data per airspace type in the 2015 timeframe for ATS communications are:

- **Airport**: Voice is used as the primary means of flight crew-Controller tactical exchanges and as a back-up for the loss of a data service. Data link is used as the primary means for appropriately equipped aircraft for other messages.

- **Terminal Maneuvering Areas (TMA's)**: Voice is used as the primary means of flight crew-Controller tactical exchanges and as a back-up for the loss of a data service. Data link is used as primary means for routine and repetitive messages (e.g., ATC Communications Management (ACM) transfers, approach information and clearances) with equipped aircraft.

- **En Route**: Data link is used as the primary means for most exchanges with equipped aircraft; including aircraft state and intent data. Voice is used for tactical clearances and emergency messages, and as back-up for the loss of a data service.

- **Oceanic/Polar**: Data link is used as the primary means for most exchanges with equipped aircraft. Voice is only used for non-routine and emergency messages, and as back-up for the loss of a data service.

In the 2015 timeframe, the assumptions are that 60% of ATS communications are provided via voice in the Airport/TMA environments, 40% of ATS communications are provided via voice in the En Route airspace and 5% of all communications in Oceanic/Polar domains are conducted via voice.

In general, the trend beyond 2015 will be a decreased use of voice and an increased use of data link as the equipage rates of aircraft and ANSP ground systems provide for the practice of using data link and building confidence in this form of communications.

Note: The Services referred to in the following are defined (including acronyms) and described in Section 3. Other acronyms used below are defined in Appendix A. Also, the Services listed in the following scenarios are not all-inclusive of the Services listed in Section 3.

2.2.2   Pre-Departure Phase

Note: In all of the following phases, the information known to one system (e.g., tower Flight Data Processing System) will be provided to all users on a network-based infrastructure. Therefore, no specific events of notification are stated in the steps below.

The aircraft operator provides gate/stand information, aircraft registration/flight identification and estimated off block time via the ground-ground communications system to other users (Airport, ATC, etc.). The flight crew prepares the aircraft for the flight and in particular, provides the necessary inputs and checks in the Flight Management System (FMS). They activate the data link system and send the initiation data to AOC while a Data Link Logon **(DLL)** takes place automatically without further flight crew involvement. Logon and contact with the ATC automation system is performed by the **DLL** service which encompasses all data link exchanges required to enable the other data link services. The flight crew requests the **Flight Plan** from AOC and inputs the AOC-provided flight plan data into the FMS. The flight crew consults relevant aeronautical information (e.g., Planning Information Bulletins, Notices to Airmen (NOTAMs), and Aeronautical Information Charts) concerning the flight. The flight crew takes responsibility for the flight in accordance with the AOC and ATM optimized and negotiated planned profile. Real-time information on the flight's departure is available in the ATC automation system.

The flight crew initiates a request for a Data Link Operational Terminal Information Service (**D-OTIS)** contract for the departure airfield. The Flight Information Service system response provides all relevant information for the weather, Automatic Terminal Information Service (ATIS), and field conditions plus the local NOTAMS.

The flight crew requests his Departure Clearance (DCL) from the system via the **DCL** service.   The tower sequencing system integrates the flight into an overall arrival/departure sequence taking into account any Air Traffic Flow Management (ATFM) constraints and assigns the appropriate runway for take-off. The automation system provides the **DCL** response including an updated calculated take-off time (CTOT) via data link to the flight crew.   The automation system updates the integrated Arrival/Departure Manager system (AMAN/DMAN) and subsequent centers with the CTOT. A suitable time after delivery of the **DCL** response, the Air Traffic Services Unit (ATSU) performs a Flight Plan Consistency (**FLIPCY)** check of the FMS flight plan data.

In low visibility conditions, the flight crew may also use the Data Link Runway Visual Range (**D-RVR)** service to request RVR information for the departure and the destination airports. For data link equipped aircraft preparing to taxi, the current graphical picture of the ground operational environment is uplinked and loaded using the Data Link Surface Information Guidance (**D-SIG)** Service.

The **Loadsheet Request** is sent to AOC. The **Loadsheet Response**, with the "dangerous goods notification information" and the last minute changes to the weight and balance of the cargo are sent by the AOC to the aircraft and are automatically loaded into the avionics. Some of this data will remain available for the Data Link Alert (**D-ALERT)** service throughout the flight, should an emergency occur. During this pre-flight phase, the Data Link Flight Update (**D-FLUP)** service will make a valuable contribution to the preparations for the flight and the flight crew specifies preferences that should be considered by the controllers using the flight crew Preferences Downlink (**PPD)** service.

The flight crew requests a "Start Up and Push Back Clearance" via the Data Link Taxi (**D-TAXI)** Service. The sequencing system calculates the planned taxiing time and after comparison with the issued CTOT, issues the **D-TAXI** response. For appropriately equipped aircraft, the **D-TAXI** route is superimposed over the **D-SIG** information previously received. The flight crew pushes back and starts up the engines in accordance with Airport procedures. The push back generates an Out-Off-On-In (**OOOI)** message to AOC advising that the flight has left the gate/stand.

As the aircraft pushes back, its Automatic Dependent Surveillance-Broadcast (**ADS-B)** system is turned on, the Advanced Surface Movement Guidance and Control System (A-SMGCS) picks up the broadcast surveillance message and associates the aircraft with the ATC flight plan. The sequencing tool updates the times for the overall arrival/departure sequence. For short-haul flights (<250 NM), the updated information is provided to the integrated AMAN/DMAN at the arrival airport.

The conflict probe system of the first ATSU analyses any potential conflicts caused by the proposed trajectory of the departing flight and informs the Planning Controller concerned with the flight. The Planning Controller uses the information to update the planning process.

Note: In 2015, it is envisioned that ADS-B/TIS-B is predominantly available in regional pockets of implementation. The use of ADS-B/TIS-B for ATS surveillance is therefore confined to these regions. Once ADS-B/TIS-B is activated, it provides a continuous broadcast of own-ship and traffic positional information which can be used by any receiver. Therefore, events subsequently described will not continually state this function unless it is necessary to clarify the operational service.

2.2.3 Departure Taxi

The flight crew requests the **D-TAXI** clearance from the tower ground controller. The tower ground controller issues the **D-TAXI** response. The flight crew maneuvers the aircraft according to the taxiing instructions. The Tower Ground Controller monitors the taxiing of the aircraft assisted by A-SMGCS and intervenes if required.

The ATC automation system generates a transfer message for the tower ground controller that control will be passed to the tower runway controller frequency automatically via

ACM on reaching the handover point. The tower runway controller issues the "Line Up and Wait Clearance" by voice to the flight crew in accordance with the traffic situation. The tower runway controller issues the voice "Take Off Clearance" to the flight crew in accordance with the traffic situation.

The ATC automation system forwards the **DLL** information via ground/ground communications to subsequent ATSUs so that air-ground data link (AGDL) with respective controllers can be conducted.

The flight crew commences the take off run. The ATC automation system detects that the aircraft is airborne and disseminates the information to the flow manager, neighboring sectors' and centers' Planning Controllers, and air defense and makes them available for other users. An **OOOI** message is sent to AOC that the aircraft is airborne.

The ATC automation system generates a transfer message for the tower runway controller and via **ACM** provides the frequency to contact the next sector Executive Controller to the aircraft.

2.2.4   Departure in TMA

When the aircraft is airborne, the flight crew contacts the first sector Executive Controller using voice. The ATC automation system determines the exit conditions from the first sector. The conflict probe checks to see if the entry conditions into the next downstream sector are conflict free. The ATC automation system performs silent coordination with the downstream sector.

The Executive Controller issues instructions via the ATC Clearances (**ACL)** service (voice or data), depending on the tactical nature of the situation, to the flight crew to achieve the exit conditions to enter the next sector and provides this clearance information to the ATC automation system. The conflict probe provides to the Planning Controller and Executive Controller information about potential interactions with other aircraft or airspace within the next 15 minutes.

The flight crew flies the aircraft according to the instructions given.   The ATC automation system monitors that the aircraft behavior is according to the given clearances.   The System Access Parameters **(SAP)** service is initiated by the ATC automation system and the downlinked information is provided to the various ground components (e.g., for smoothing of trackers), or on request for display of parameters to controllers. The tracking system issues warnings to the Executive Controller in case of non-compliance.   The Executive Controller intervenes if the situation requires action. The tracking system uses the **ADS-B** and radar data to monitor if the aircraft performance is according to the ground predicted trajectory, and updates the trajectory where necessary.

The Executive Controller transfers control of the aircraft to the next sector Executive Controller. The data link processing system provides the next frequency to the flight crew via the **ACM** service and transfers the AGDL services to the next sector/ATSU.

2.2.5 En Route/Oceanic/Polar

Note: In 2015 a typical continental flight will pass through four En Route facilities. Long haul flights will traverse numerous En Route facilities. The number of sectors traversed within each En Route facility is typically five. The exchanges that occur from a communications stand-point are the same in each en route facility, so the following description does not specify inter vs. intra facility transfers or ATC automation system events unless necessary for clarity of the scenario.

The ATC automation system confirms/sets the exit/entry conditions with the sectors in the en route phase. At each entry into a subsequent ATSU, **FLIPCY** is performed. The ATC automation system performs a Flight Plan Intent **(FLIPINT)** contract (e.g., periodic, event, etc.) with equipped aircraft while in each ATSU's area of jurisdiction. The Executive Controller decides and performs, or has the Planning Controller perform, **ACL** as necessary, and initiates handovers to the next sector/ATSU. The ATC automation system supports handover by communicating the event to the flight crew and the downstream sector/ATSU via **ACM**. The flight crew contacts or monitors the frequency of the receiving sector Executive Controller when the handover is performed. Meanwhile, the aircraft begins providing periodic **Engine Performance Reports** to the AOC. The controller team accesses the **PPD** information from the aircraft to determine if any of the flight crew preferences affect or could improve the planned trajectory. The flight crew initiates the Graphical Coordination of Trajectory **(GRECO)** service to request a modification to the current trajectory. The Planning Controller assesses the request against the conflict probe. If no conflicts are found and after informing the Executive Controller, the **GRECO** response is sent via **ACL**. An aircraft system notices a minor fault that generates a **Flight Status** message to AOC for maintenance action upon arrival.

During this phase of flight, the aircrew initiates the request for a Down Stream Clearance **(DSC)** with the D-ATSU for the Oceanic/Polar portion of the flight. The D-ATSU receives this request and determines if the requested profile can be approved. The result is provided to the Planning Controller for authorization and the resulting **DSC** response is sent to the aircraft. The Planning Controller in the D-ATSU coordinates the changed entry point with the C-ATSU Planning Controller. The changed entry point requires an update to the aircraft current trajectory in order to comply with the entry restriction. This is coordinated with the Executive Controller in the C-ATSU and is then sent to the aircraft via **ACL** and an update is provided to the flight data processing system. The **ACL** could also have been undertaken by voice if necessary.

Prior to entry into the oceanic/polar domain, a weather report is provided to the Planning Controller indicating that moderate to severe turbulence may be expected over this

portion of the flight. This information is sent to the aircraft via the Data link Significant Meteorological Information **(D-SIGMET)** service.

The aircraft progresses through the Oceanic/Polar domain. The aircrew requests a more efficient altitude via **ACL**. Due to traffic, the **ACL** response includes the requirement to execute an In-Trail Procedure **(ITP)** using **ADS-B** information on the flight deck display between a pair of **ADS-B**-equipped aircraft. The progress of the flight is monitored by an **ADS** contract between the aircraft and the ANSP. Any events that cause the aircraft to be in non-compliance with the planned trajectory are communicated with appropriate alerting to the Executive Controller.

The aircraft returns to the En Route domain in accordance with the previously planned trajectory. The aircraft position causes a **Fuel Status** message to be sent to AOC. The ATC automation system sets the exit conditions (target time) taking into account restrictions at the destination airport (if applicable in this sector). The AMAN calculated time is sent to the aircraft via Arrival Manger Delivery **(ARMAND)** service. The conflict probe system provides the Planning Controller and the Executive Controller information about potential conflicts with other aircraft within the next 15 minutes.

The Planning Controller analyses interactions with other aircraft that are reported to him by the conflict probe system. The Planning Controller probes "What if" solutions for interactions. The conflict probe system may offer alternatives to the existing route and these alternatives are assessed by the Planning Controller, and then the alternatives are provided via the Dynamic Route Availability **(DYNAV)** service for flight crew assessment. The Planning Controller enters the flight crew-selected alternative and updates the flight trajectory in the ATC automation system. The Executive Controller is notified about the required change to the trajectory of the aircraft and issues the **ACL** instructions to the flight crew to achieve exit conditions to enter the next sector.

The Planning Controller, in coordination with the Executive Controller, occasionally issues data link instructions to the flight crew via **ACL** for cases where a maneuver is planned at a later stage, (e.g., >2 minutes from current flight position). Otherwise, the Executive Controller provides instructions via **ACL** (voice or data) as determined by the tactical nature of the situation. The flight crew flies the aircraft according to the instructions given. The ATC automation system recognizes the aircraft's position relative to exiting the ATSU and compiles a Data Link Operational En Route Information Service **(D-ORIS)** report specific to the remaining portion of the area to be over-flown and sends it to the aircraft.

The ATC automation system uses the **ADS-B** and radar information to monitor that the aircraft behavior is conforming to the given clearances and issues warnings to the Executive Controller in case of non-conformance, who intervenes via voice or data if a situation requires action.

The Executive Controller initiates a transfer of the aircraft to the next sector. The data link processing system provides the next frequency to the flight crew via **ACM** and transfers the AGDL services to the next sector.

The AMAN system notifies the Planning Controller and the Executive Controller about Top of Descent (TOD) at a time parameter prior to the TOD position. The conflict probe indicates a conflict is manifested if the aircraft is to comply with the TOD calculation. A Sequencing and Merging **(S & M)** operation is required to mitigate the conflict. As the Aircraft reaches the TOD position, an **ACL** instruction containing **S & M** instructions is issued which implements with the needed trajectory.

2.2.6   Arrival in TMA

The system updates AMAN with changes to the arrival sequence. AMAN calculates constraints taking into account the actual traffic situation and makes the information (time to lose/gain or hold) available to the Planning Controller and the Executive Controller concerned in upstream sectors/ATSU's. If required, the conflict probe system calculates a conflict-free alternative trajectory for the flight to comply with the AMAN constraints. The Planning Controller of the receiving sector checks the **PPD** service information to see if the conflict probe system-provided trajectory can be improved with these preferences. The Planning Controller accepts the proposal and coordinates the sending of the **ACL** instruction with the Executive Controller.

Based on the information obtained via **SAP** and **PPD**, the executive controller determines which aircraft may execute a spacing application and issues **S & M** clearances to those aircraft via **ACL**.

At this time, the Executive Controller determines that the voice communication frequency in use has been blocked by an airborne user. In order to address this concern and free the voice channel for communications, the Planning Controller initiates an uplink of the ATC Microphone Check **(AMC)** service to all aircraft with whom communications is required. Within moments, the blockage of the frequency is resolved and the Executive Controller returns to voice communications for tactical instructions as necessary.

The flight information system provides requested Data Link Automatic Terminal Information Service **(D-ATIS)** information to the aircraft. The Aircraft Operator informs the flight crew via data link and Tower Ground Controller via ground/ground communications about **stand/gate allocation**. The flow management system provides STAR allocation, runway for landing, and AMAN constraints to the Planning Controller who reviews, approves, and after coordination with the Executive Controller, sends them via **ACL**.

The Executive Controller instructs the flight crew to descend. The FMS flies the aircraft according to the given instructions to the Initial Approach Fix (IAF) and generates a final

Fuel Status report to AOC for refueling planning. The tracking system uses **ADS-B** and radar data to monitor that the aircraft behavior is according to the given clearances and issues warnings to the Executive Controller in case of non-compliance. The Executive Controller can intervene via voice if a situation requires immediate action.

The Executive Controller issues instructions to the flight crew to follow the calculated profile for final approach via **ACL**. The flight crew reports: "Established on Final Approach." The Executive Controller instructs the flight crew to contact the Tower Runway Controller via **ACM**.

The Tower Runway Controller monitors the traffic situation and intervenes if required. The Tower Runway Controller issues the "Landing Clearance" to the flight crew. The Tower System provides a recommended **D-TAXI** runway exit and the taxi-in route plan to the Tower Runway Controller. The Tower Runway Controller issues the **D-TAXI** instructions to the flight crew via **ACL**.

The flight crew lands the aircraft. The avionics detects touch down and disseminates this **OOOI** information to the AOC together with data about the wind on final approach. The common network system makes this information available to other users. AOC responds to the **OOOI** message with a **Flight Log Transfer** message to inform the crew of the next flight assignment. The A-SMGCS informs the Tower Runway Controller about the aircraft vacating the runway. The Tower Runway Controller instructs the flight crew to contact the Tower Ground Controller via **ACM** (voice or data).

2.2.7   Arrival Taxi

The A-SMGCS uses **ADS-B** and radar data to notify the arrival sequence of the aircraft to the Tower Ground Controller. The Tower Ground Controller uses the **D-TAXI** information to verify the aircraft's assigned route from the landing runway nominated exit point to the gate before landing.

The flight crew contacts the Tower Ground Controller. The Tower Ground Controller clears the flight crew to follow the taxi-in route plan. The flight crew maneuvers the aircraft according to the instructions. The Tower Ground Controller monitors the traffic situation and intervenes if required. A-SMGCS calculates in real-time the Target Taxi-In Period and uses a combination of **ADS-B** and radar information to monitor the traffic situation for the detection of potentially hazardous situations (e.g., aircraft speed, conflict between aircraft and with service vehicles or obstacles or airport infrastructure) and issues warnings to the Tower Ground Controller as required.

The A-SMGCS detects "on block" and disseminates the **OOOI** information to the Aircraft Operator and makes the information available for other users. The flight crew informs the Tower Ground Controller: "Finished with engines."

2.3   Concept Trend for 2030

The ATM system has been evolving constantly since 2015. All ATM stakeholders are fully participating in the Layered Planning Process and the use of Collaborative Decision Making (CDM) Processes is routine and commonplace. As the planning process itself is now mature, the focus of change has shifted from developing the process to including additional information into the process. This has improved and widened the database for situational awareness and consequently makes the CDM Processes faster and decreases uncertainty in decision making.

The adherence to the concept of Layered Planning and the philosophy of CDM has driven the development of homogeneous procedures, and the integration of systems and services for exchange of information. The integration has evolved over time from simple standardization of interfaces in the beginning, via local "islands of integration," e.g., at aerodromes, to a system wide integration including air and ground elements as well as planning and executive levels.

In 2030, the integration of air/ground systems has evolved to an extent enabling common use of up-to-date information in a seamless and economical way. The information used in integrated systems comprises data from various sources, be it in the air or on the ground (e.g., FMS, AMAN), of different natures (e.g., intent data, forecast data), and of different urgency and priority (e.g., emergency communication, planning information). Common rules and standards are in place for the use of integrated systems and for the treatment of information and data. The focus of development and change has been the planning processes, where communication and information exchanges between ATM stakeholders became more important, decision making processes became collaborative as common situational awareness of the ATM stakeholders developed, and the roles and responsibilities evolved. The use of trajectory negotiations has become the norm. The evolution from **GRECO to** Common Trajectory Coordination **(COTRAC)** has taken place, helped by the reorganization of airspace and the emergence of avionics that allow the creation of a 4D trajectory, unrestricted by the number of points needed for its definition. The airspace has been segregated to allow the use of both trajectory control applications, as well as more flexible spacing and self-separation applications. Together with the air/ground integration, the transformation of positive control of traffic to management of the resource is completed. This paradigm change has defined the ATM System and the ATM environment in 2030.

The full implementation of the services described in Section 3, along with supporting automation systems, have allowed an increase in the amount of aircraft monitored by a given controller team. Airspace has been reorganized to maximize the efficiency of the services/tools available to the Controller/flight crew. The segregation of the airspace is done according to the services offered by the ANSP in the airspace they are managing (e.g., use of **COTRAC** above FL 200 and self-separation applications below FL 200 for the approach phase). Sector boundaries are now routinely changed to accommodate the division of labor amongst controllers as traffic/weather conditions warrant.   The

communications resources associated with the airspace are all network based and are reassigned as needed to provide coverage for the new sector layouts.

Beyond the full implementation and use of the planning and decision making processes, air/ground automation tools, and the services, the most significant change to the concept previously described in 2015, is the commonplace use of shared or transferred separation responsibility between flight crews and controllers. Aircraft and ANSP equipage and service implementation has been completed. Separation standards in all domains have been reduced to that which is required to avoid the wake turbulence of the other aircraft or meet a particular time of arrival at a significant point. Use of the cockpit display to provide air traffic situation awareness (ATSAW) of all aircraft in the vicinity and determine their intent, has provided the basis for this routine sharing or transferring of separation responsibilities.

Note: Sharing is where a pair of aircraft manage their own separation between themselves while ATC is providing separation from all other aircraft. Transferring is where the separation responsibility for all aircraft in a given area is transferred to the aircraft involved.

Another revolution that has taken place is in the aircraft population. A new breed of "microjets" was developed to satisfy the need for unrestricted access to travel on an as-needed basis. These aircraft operate primarily from rural airports; basically on-demand, or with little to no prearranged travel planning required and are competitively priced with the conventional commercial air transportation industry. According to the U.S. JPDO, the sheer number, ~13,000 in 2025, of these aircraft has changed the dynamics of the system we knew in 2015. On any given day, this type of aircraft can represent 40% of the daily traffic load.

Where once we had a hub and spoke operation with many medium size (e.g., 100-140 passenger) aircraft, the industry now consists mainly of larger (e.g., 225 or more passenger) aircraft conducting trans and inter-continental travel operating from the major metropolitan airports and the microjets, carrying 6-12 passengers, catering to short haul domestic travel from your own home town.

Another new type of aircraft operation that is now common and routine, is remotely operated aircraft (ROA) or unmanned aerial vehicles (UAV). According to the U.S. JPDO, these aircraft, ~20,000 in 2030, operate predominantly for military, cargo, agricultural or security operations, and additionally, some limited passenger services are provided between major airports and downtown locations using aircraft capable of vertical takeoff and landings (VTOL).

This shift in the aircraft population has stressed the capacity of the ATM system. While it took some time to integrate these aircraft into the planning and decision making process, once all shareholders understood how to work with the system, the increased burden of these operations became manageable. UAV's, microjets, and all other aircraft

operate alongside each other without any user needing to be treated differently. The planning process is so well known, and collaboration amongst the stakeholders is so routine that the related problems experienced in the 2015 timeframe have disappeared.

Managing the flow of traffic has also become a routine task. Free route operations are allowed up to an entry point into the sequencing pattern typically 20 miles from the destination. Aircraft flight prediction tools have managed to define the way traffic is regulated. All traffic is metered from before take off to arrival at the gate using four dimensional trajectory negotiations. Users need only notify the controller if there is a need to change the trajectory, otherwise communication with the aircraft is mostly controlled by the System as it monitors the traffic.

2.4 Scenario in 2030

2.4.1 Communication Allocation between Voice and Data

The assumptions of operational use among voice and data per airspace type in the 2030 timeframe for ATS communications have evolved to the following:

- **Airport**: Data link is used as the primary means of flight crew-Controller exchanges. Voice is used for non-routine and emergency messages and as a back-up for the loss of a data service.

- **TMAs**: Data link is used as the primary means of flight crew-Controller exchanges. Voice is used for non-routine and emergency messages and as a back-up for the loss of a data service.

- **En Route**: Data link is used as primary means for most exchanges with aircraft. Tactical clearances are almost non existent but voice remains for these non-routine and emergency messages, and as a back-up for the loss of a data service.

- **Oceanic/Polar**: Data link is used as primary means for almost all exchanges with aircraft. Voice is only used for non-routine and emergency messages, and as back-up for the loss of a data service.

In the 2030 timeframe, it is assumed that 85% of ATS communications are provided via data link in the Airport/TMA environments, 95% of ATS communications are provided via data link in the En Route airspace and 99% of all ATS communications in Oceanic/Polar domains are conducted via data link.

2.4.2 Pre-Departure Phase

The only change in the Pre-Departure phase has been the increased equipage of aircraft and ANSP ground systems. The mode of operation described in the 2015 scenario is now in common use for all aircraft. In particular, aircraft equipage has evolved to the point where every aircraft is now equipped with a cockpit display capable of high definition

graphics. This allows the use of advanced concepts in ATM, based on graphical depictions of the ATSAW picture, to be commonplace.

The issuance of a **DCL** now involves the negotiation of a highly constrained trajectory using the **COTRAC** service. The negotiation of the trajectory is done in accordance with the principles of CDM (involving the airline) to ensure that the airspace users' needs are considered. The final point in the clearance includes the required constraint for the arrival airport provided by the ground system.

2.4.3 Departure

There are no new services impacting only the TMA domain. Services described in 2015 are used on a regular basis with all aircraft at an increased rate due to the increased traffic and equipage. The aircraft follows the 4D trajectory previously negotiated through **COTRAC**.

2.4.4 En Route/Oceanic/Polar

The aircraft continues to execute the trajectory previously agreed via the **COTRAC** Service. Changes to this contract are more in the context of an overall trajectory maintenance service instead of as individual 4D events.

As the use of these services and the nature of ATC have evolved, the communications requirements have evolved also. Trust in the system's performance has become commonplace. Routine exchanges are no longer needed. Everything the flight must do is embedded in the **COTRAC** agreement. Execution of **S & M, C & P, and ITP** services for **ADS-B** equipped aircraft are routine and conducted via **ACL**. Communications transfers via **ACM** occur automatically without controller/aircrew involvement through the **Auto-CPDLC** Service. **ADS** agreements between the aircraft system and the ATC automation system are now in place with all aircraft and reports are only generated when an event occurs beyond the parameters set in the **COTRAC** agreement. The aircrafts COTRAC trajectory takes into account the computational process of the arrival time constraint set by the AMAN system.

2.4.5 Arrival in TMA

Arriving at the entry point into the TMA, the aircraft is instructed via **ACL** to use the **S & M or ITP** services to self-separate in the approach phase from traffic landing at the same destination. This is a next step from the use of the spacing applications that were introduced in 2015 and by now have become standard.

2.4.6 Arrival Taxi

The Arrival taxi phase is now coordinated before the aircraft begins the final descent for landing. The **D-SIG** surface map and **D-TAXI** overlay is communicated in advance of the landing clearance so that the aircrew can determine any impacts to its configuration. All the 2015 services continue to be in use unless superseded, but as aircraft equipage increases, more aircraft will be eligible for the services.

3 OPERATIONAL SERVICES

3.1 Introduction

Although the focus and definition of the following services is on data communications expected to be available by 2015, most of these applications will also continue to be supported by voice when the time criticality of the transaction requires it. Some ATS services would not be operationally possible or effective if implemented by voice. These services are designated by an asterisk (*) in the header text for the associated section.

Several of the message elements and parameters used by the services described in this document are not covered by the ICAO ATN SARPS.

Further validation through a full end-to-end technical interoperability, specification process, safety and performance assessment, trials and actual operations (for example, clearances involving a controller without radar control) should be undertaken in order to mitigate the risks associated with global implementation.

3.2 Air Traffic Services

3.2.1 Controller/flight crew ATS Services

As Air/Ground data communications for ATS is a recent development and necessitates a very complex system involving interaction from end-to-end of humans and systems, many operational and technical questions need to be answered before contemplating full operations. However, it is expected that the current operational concept involving extensive use of a tactical intervention process supported by voice will evolve towards a "tactical intervention by exception" process supported by timely use of various data link services. Although services expected in 2015 will continue to support the current operating concept, evolution toward the 2030 timeframe will tend toward a concept involving a contract for and maintenance of a user-preferred 4D trajectory, requiring little, if any, manipulation in a tactical sense.

For ease of understanding the air traffic services included below, Figure 3-1 shows a typical flight profile, ATM phases of flight, the major events and ATS services supporting the user. The data link services in non-italics are expected to be available, to varying degrees in 2015. Those 2030 services in italics will not be available until after 2015 and may replace some 2015 services as discussed in the preceding chapter's operational scenarios. By 2030 all remaining services are expected to be widely available and in use.

In addition, the service domain of each service is shown to the right of the service.

Figure 3-1 — table:

Flight Events		Request Start-Up	Take-Off	Cruise Level		Parameter from Destination	Landing
ATM Phase	Tactical Planning	Airport	Departure	En-Route/Oceanic/Polar		Arrival	Airport
Units and Facilities Involved	IFPS CFMU FMPs	TWR APP ACC IFPS FMPs	APP ACC(s) IFPS FMPs	ACC(s) IFPS FMPs		ACC(s) APP	TWR

Data link Services — Data link Service Domain

Data link Services	Tactical Planning	Airport	Departure	En-Route/Oceanic/Polar	Arrival	Airport
- ACM/DLL (incl Auto CPDLC)		✈	✈	✈	✈	✈
- ACL (Incl Auto CPDLC)		✈	✈	✈	✈	✈
- DCL		✈				
- DSC		✈	✈	✈		
- PPD		✈	✈	✈	✈	
- FLIPCY		✈	✈	✈	✈	
- FLIPINT			✈	✈	✈	
- AMC	✈	✈	✈	✈	✈	✈
- D-FIS (ATIS, OTIS, ORIS, SIGMET, FLUP, RVR)	✈	✈	✈	✈	✈	
- D-TAXI		✈				✈
- D-SIG		✈				✈
- ADS-B	✈	✈	✈	✈	✈	✈
- D-ALERT		✈	✈	✈	✈	✈
- SAP			✈	✈	✈	
- ARMAND				✈		
- GRECO			✈	✈	✈	
- COTRAC		✈	✈	✈	✈	
- URCO		✈	✈	✈	✈	✈
- DYNAV		✈	✈	✈		

Figure 3-1. Air Traffic Services by Flight Phase

3.2.1.1 Voice ATS Services

All current air/ground and air/air voice communications functions, as they exist today, will continue to be supported in the 2015–2030 timeframe. Despite existing limitations, voice communications have some advantages over data which need to be available: speed of transmission, human tone which can express urgency or other important feelings, flexibility of dialogue, provision of a party line or broadcast effect. Therefore, the system should be developed such that the best of voice and the best of data will be used by operational staff on the basis of ATS needs and as dictated by the operational circumstances. The specific ratio of voice to data is derived from these services and other trend information.

Note: Point-to-point selective addressed voice between the controller and flight crew is not a requirement, nor is point-to-point addressed data between flight crews.

The following list of ATS addressable services, described more fully in the subsections that follow, are considered not to be operationally effective if implemented by voice.

Although some services, such as Data Link -TAXI, are indicated as data link services, the information might also be provided by voice.

1. ATC Microphone Check
2. Data Link Surface Information and Guidance
3. flight crew Preferences Downlink
4. Dynamic Route Availability
5. Graphical Enabler for Graphical Coordination
6. Common Trajectory Coordination
7. Flight Plan Consistency Check
8. Flight Plan Intent
9. Data Link Alert
10. Data Link Logon

3.2.1.2   ATC Clearance (ACL)

An aircraft under the control of an ATSU transmits reports, makes requests and receives clearances, instructions and notifications through ACL. The ACL service specifies the aircraft/Controlling (C) – Air Traffic Services Unit (ATSU) dialogue exchanges via air/ground communications. ACL can be voice, data link, or combination of voice and data link communications. This service is the basic building block for trajectory conformance management.

3.2.1.3   Automatic Controller-flight crew Data Link Communications (Auto-CPDLC)

Auto-CPDLC is automatic preparation and sending of messages to a single or multiple aircraft (multicast). Other non-tactical messages (e.g., squawk changes) can also be delivered in this way.

3.2.1.4   *ATC Microphone Check (AMC)

When the voice channel is blocked, such as when an aircraft has a stuck microphone, the AMC Service provides an alternative to voice communication for contacting other aircraft, as well as the one with the stuck microphone, via data link. This allows a message to be dispatched to some or all aircraft being controlled by that sector/position.

The AMC Service is a one-way uplink and requires no response.

3.2.1.5 Data Link Taxi Clearance Delivery (D-TAXI)

A flight due to depart from an airport, or an aircraft that has just landed, must obtain a series of clearances from the Controlling Air Traffic Service Unit in order to proceed from/to its stand to/from the runway. This is a specific use of ACL on the ground. The objective of the D-TAXI Service is to provide automated assistance to Controllers and flight crews to perform these communication exchanges during ground movement operations.

3.2.1.6 *Data Link Surface Information and Guidance (D-SIG)

The D-SIG Service provides automated assistance to flight crews by delivering a current, static graphical airport map. D-SIG presents an updated (e.g., taxiway closures, runway re-surfacing) and integrated representation of all the airport elements necessary for ground movements to the flight crew. Adding the visual representation of taxi routes provided by D-TAXI to the D-SIG Service complements this goal.

3.2.1.7 Departure Clearance Service (DCL)

A flight due to depart from an airfield must first obtain departure information and clearance from the C-ATSU. The DCL Service provides automated assistance for requesting and delivering departure clearance and related route of flight information.

3.2.1.8 Down Stream Clearance (DSC)

In specific instances, flight crews need to obtain clearances or information from ATSUs that may be responsible for control of the aircraft in the future, but are not yet in control of it.

The DSC Service provides assistance for requesting and obtaining Down Stream ATSU (D-ATSU) clearances or information using air/ground data link. The DSC Service is a specific instance of ACL with a D-ATSU that can only be initiated by the Aircrew. For example, this service could be used in the absence of ground/ground coordination capability.

3.2.1.9 *Pilot Preferences Downlink (PPD)

Aircrews have preferences on the way the flight is to be conducted for various operational reasons. In order to execute pertinent control strategies, controllers need to be aware of these preferences. The PPD Service allows the aircrew, in all phases of a flight, to provide the Controller with a set of preferences not available in the filed flight plan (e.g., maximum flight level) as well as requests for modification of some flight plan elements (e.g., requested flight level).   It automates the provision to Controllers of selected Aircrew preferences even before the aircraft reaches their sector.

3.2.1.10 *Dynamic Route Availability (DYNAV)

The objective of the DYNAV Service is to automate the provision of route changes when alternative routings can be offered by the ATSU, even before the flight is under their control. For example, aircrews can be offered routes that have become available due to lifting of military Special Use Airspace reservations, dissipation of weather or other operational restrictions.

3.2.1.11 Arrival Manager (AMAN) Information Delivery Service (ARMAND)

ARMAND automatically transmits relevant arrival manager advisories directly to flight crews that are within the optimum horizon of the AMAN, but may be beyond the limits of the ATSU that contains the flight's destination airport.

The ARMAND service transmits target, expected or revised approach time advisories relevant to the destination airport. This exchange may subsequently be followed by an ACL transaction.

When COTRAC becomes available, ARMAND will be superseded for those equipped.

3.2.1.12 *Graphical Enabler for Graphical Co-ordination (GRECO)

The purpose of GRECO is to establish revised route contracts between flight crew and Controllers during the flight using graphical interfaces and automation systems, in particular the FMS.

GRECO gives flight crews the freedom to choose how they meet ATC constraints by creating one new constraint – eventually returning to the planned route. The flight crew or controller could initiate the coordination via a 4D downlink request. When COTRAC becomes available, it will allow changes to multiple constraints and thereby obviate the need for GRECO.

3.2.1.13 *Common Trajectory Co-ordination (COTRAC)

The purpose of COTRAC is to establish and agree on 4D trajectory contracts in real time using graphical interfaces and automation systems, in particular the FMS. COTRAC differs from and may replace GRECO in that it will allow new trajectory contracts involving multiple constraints (latitude/longitude, altitude, airspeed, etc.).

3.2.2   Automated Downlink of Airborne Parameter Services

3.2.2.1   *Flight Plan Consistency (FLIPCY)

The **FLIPCY** Service provides information to detect inconsistencies between the ATC used flight plan and the one activated in the aircraft's Flight Management System (FMS). This information may generate an uplink ACL message to resolve the inconsistency.

3.2.2.2   *Flight Path Intent (FLIPINT)

The **FLIPINT** Service consists of the down-linking of the trajectory predicted by the FMS (ADS [Contract]) together with some additional information in order to support the Flight Data Processing System trajectory prediction. FLIPINT includes a FLIPCY data function plus FMS ETA, velocity prediction, airborne winds, etc.

3.2.2.3   System Access Parameters (SAP)

The scope of the SAP Service is to make specific, tactical flight information (instantaneous indicated heading, air speed, vertical rate, and wind vector) available to the Controller or ground automation by extracting the relevant data from the airborne system. The use of the SAP parameters by the ground system should be considered as a means to provide enhancements to the existing ATC surveillance functions. The SAP Service can be periodic or event driven and is available in all phases of flight.

3.2.3   Flight Information Services

Note: Delivery can be implemented through local broadcast, addressable point-to-point ground/air communications or both.

3.2.3.1   Data Link Operational Terminal Information Service (D-OTIS)

The **D-OTIS** service provides flight crews with compiled meteorological and operational flight information derived from ATIS, METARs, NOTAMs, and PIREPs specifically relevant to the departure, approach and landing phases of flight.

3.2.3.2   Data Link Runway Visual Range (D-RVR)

The D-RVR Service provides flight crews with up-to-date RVR information related to an airport's runway(s). At any time of their choosing, the flight crews can request RVR information related to any airport's runway(s).

3.2.3.3 Data Link Operational En Route Information Service (D-ORIS)

The D-ORIS Service provides flight crews with compiled meteorological and operational flight information, derived from "En Route" weather information, from NOTAMs, as well as from other sources, specifically relevant to an area to be over-flown by the aircraft or any area of interest in the en route domain.

3.2.3.4 Data Link Significant Meteorological Information (D-SIGMET)

The purpose of D-SIGMET information is to advise flight crews of the occurrence or expected occurrence of weather phenomena that may affect the safety of aircraft operations. The preparation and issue of SIGMET reports is the prime responsibility of meteorological watch offices (MWO). SIGMET information messages are distributed on ground initiative to aircraft in flight through associated ATS units.

3.2.3.5 Data Link Automatic Terminal Information Service (D-ATIS)

D-ATIS provides terminal information relevant to a specified airport(s) in any phase of flight. Weather, active runway(s), approach information, NOTAM information is provided by data link rather than by voice.

3.2.3.6 Data Link Flight Updates Service (D-FLUP)

The D-FLUP Service provides all the ATM-related operational data and information aimed at the optimization of the flight preparation supporting punctual departure. Examples of this data include information related to the departure sequence, CDM agreements, slot time allocations, as well as to airborne target approach times. Special operations such as de-icing will be included in this service.

3.2.4 Traffic and Surveillance Services

3.2.4.1 Automatic Dependent Surveillance – Broadcast (ADS-B)

ADS-B is a function on an aircraft or a surface vehicle operating within the surface movement area that periodically *broadcasts* (reports) its state vector (horizontal and vertical position, horizontal and vertical velocity) and other information.

ADS has been traditionally used in non-radar airspace to supplement command and control functions of ATS. Unlike ADS-B, ADS (Contract) downlinks *addressed* position reports to ATSUs on a contract basis. These reports have been credited with bringing order and separation confidence in the airspace where implemented.

The ADS-B system transmits and receives messages to support air-to-air and air-to-ground surveillance reports. The Minimum Aviation System Performance Standards for

ADS-B provide guidance regarding performance standards. ADS-B services currently require once/second broadcasts for use with/without other supporting systems and services, e.g., CDTI, ACL, and radar.

ADS-B is used to provide the information in various environments to support different services. These include but are not limited to:

- ATC surveillance in all domains; with or without primary or secondary radar support
- Airborne surveillance for situational awareness
- Enhanced visual acquisition
- In Trail Procedures (ITP)
- Crossing and Passing operations (C&P)
- Sequencing and Merging (S&M) operations

The ITP, C&P, and S&M services are supported by both broadcast and transactional communication. Broadcast communication is used for position information. Transactional related communication (ACL) provides the controller/flight crew instructions (e.g., merge behind target aircraft).

3.2.4.2   Traffic Information Service – Broadcast (TIS-B)

In some airspace, and for some classes of users, a ground–to-air TIS-B will be implemented. TIS-B allows the broadcast of sensor-based traffic information and/or rebroadcast of ADS-B information. Traffic information is displayed on associated aircraft avionics. TIS-B update rates may be less frequent than ADS-B update rates. Some services, such as ATC Surveillance and Airborne Surveillance for Situational Awareness, which do not rely on high update/transmission rates could be implemented through TIS-B. TIS-B is likely to be available through 2030 in some areas and for some users (such as GA), resulting in a mixed equipage environment.

3.2.5   Emergency and Ancillary Services

3.2.5.1   Urgent Contact Service (URCO)

The Urgent Contact (URCO) Service is to provide assistance for establishing urgent contact (via voice or data link) with Aircrews that may or may not be under the initiating ATSU's control at the time.

3.2.5.2 *Data Link Alert (D-ALERT)

The objective of the D-ALERT Service is to enable Aircrews to notify, by data link, designated stakeholders when the aircraft is in a state of emergency or abnormal situation (with or without declaring emergency).

3.2.6 Communications Management Services

3.2.6.1 *Data Link Logon (DLL)

The aircrew activates the data link system and DLL takes place automatically without flight crew involvement. Logon and contact with the system is performed by the DLL Service which encompasses all data link exchanges required to enable the other data link services.

3.2.6.2 ATC Communication Management (ACM)

When a flight is about to be transferred from one sector/ATSU to another, the Aircrew is instructed to change to the voice channel of the next sector/ATSU. The ACM Service provides the air/ground exchanges between an Aircraft and its transferring ATSU (T-ATSU) as well as with its receiving ATSU (R-ATSU) to establish communications control of the flight. In addition, when data link communications are involved, the ACM service manages the data link connection transfer.

3.3 Aeronautical Operational Control (AOC) Services

AOC is an important element of ATM and is needed for continued efficient operation of airspace users. AOC services are concerned with the safety and regularity of flight and as such are defined in Annex 6 of the ICAO Convention. AOC applications involve voice and data transfer between the aircraft and the Aeronautical Operations Control center, company or operational staff at an airport.

Experience to date with legacy AOC has shown that the bulk of message traffic has migrated to data communications. Requirements for AOC voice, including communication with the airspace user operations centers and between aircraft, will continue to experience a downward trend but will still be required. Based on expected increases in air traffic, AOC data communications will grow exponentially as the result of both the increase in number of messages per aircraft and size and characteristics of the message content. This trend will continue to support the need for new applications, and the availability of new technology will be exploited by airspace users. In some cases, services will be employed on a routine, periodic basis, while in other cases, instances of use will require increased bandwidth because of the nature of the service.

As the role of AOC applications continues to grow, two particular forms lead to the highest communication loads:

1. **Communications at the Gate**: Significant information exchange occurs between the aeronautical operational staff and the aircraft when the aircraft is parked at the airport. This communication covers such things as Log Book transfers and even uplink of software updates. These applications require high integrity and significant data exchange, but are not time critical.

2. **Airborne Monitoring Applications**: A number of recent AOC applications have supported real-time monitoring of aircraft performance during flight. This is likely to be a growing trend. Research is also considering the possibility of providing telemetry data via datalink to support accident investigation and other uses.

	Request Start-Up	Take-Off	Cruise Level	Parameter from Destination	Landing
Flight Events					
ATM Phase	Tactical Planning / Airport	Departure	En-Route/Oceanic/Polar	Arrival	Airport
Units and Facilities Involved	IFPS CFMU FMPs / TWR APP ACC IFPS FMPs	APP ACC(s) IFPS FMPs	ACC(s) IFPS FMPs	ACC(s) APP	TWR

AOC Data Link Services — Data Link Service Domain

AOC Data Link Services	Airport (Start-Up)	Departure	En-Route	Arrival	Airport (Landing)
- OOOI	►				►
- NOTAMs	►		►		►
- Free Text			►		
- Weather Request	►		►		►
- Position Report			►		
- Flight Status	►	►	►	►	►
- Fuel Status			►		
- Gate/Connecting Flight Status			►		
- Engine Performance Reports		►	►	►	
- Maintenance Troubleshooting			►		
- Flight Plan Request		►	►		
- Load Sheet Request	►				
- Flight Log Transfer	►			►	
- Real Time maintenance			►		
- Graphical Weather		►	►	►	
- Real Time Weather		►	►	►	
- Online Technical Troubleshooting			►		
- Technical Log Book Update				►	
- Electronic Library Update	►				
- Software Loading	►				
- Cabin Log Book Transfer				►	

Figure 3-2. AOC Services by Flight Phase

3.3.1 AOC Voice Services

Flight crew-to-Company voice services, when the aircraft is in range of the dispatch function, or when a phone patch extends that range, continue to form a small portion of

AOC communications. Flight crew-to-flight crew voice communications, especially in oceanic and polar regions comprise the remainder of AOC voice communications.

3.3.2   Out Off On In (OOOI)

Movement Service messages including; Out, Off, On, In, report data that is automatically routed to the AOC Movement Control System. This service is a one way downlink from the aircraft to AOC to report significant points in the flight's progress.

3.3.3   NOTAM Request/NOTAMs

NOTAM service delivers Automatic Terminal Information Service (ATIS) that includes any immediate NOTAMs available. This service is activated manually by the flight crew from a menu list displayed on the cockpit Control and Display Unit.

3.3.4   Free Text

Free Text Service includes miscellaneous uplinks and downlinks via textual messages between the cockpit and AOC/other ground based units. This does not include cockpit-to-cockpit exchanges. Free text can also be used to append standard pre-formatted downlink response messages such as in Oceanic Clearances.

3.3.5   Weather Request/Weather Report

Weather Request Service includes flight crew requests for airport weather. Weather reports include Meteorological Aerodrome Reports (METARs) and Terminal Area Forecasts (TAFs) which are provided via downlink messages. The AOC Flight Planning System replies by delivering the requested weather information to the cockpit.

3.3.6   Position Report

Position Report Service includes automatic downlink of position during the climb, cruise and descent portions of the flight. The primary purpose is delivery of position reports at required waypoints for use in AOC tracking systems. During all phases of flight, but principally en route, the aircrew can also manually initiate the Position Report Service.

3.3.7   Flight Status

The Flight Status Service includes, for example, malfunction reports to maintenance including fault reporting codes that allows maintenance and spares to be pre-positioned at plane side after landing. Fault reporting can be done manually, or automatically sent when triggered by an event.

3.3.8 Fuel Status

Fuel Status Service downlinks fuel state en route and prior to landing. This service allows ground services to dispatch refueling capability promptly after landing. The aircrew also reports the fuel status upon specific AOC request.

3.3.9 Gate and Connecting Flight Status

This service includes manual and automatic uplink of connecting flights, ETD, and gate before landing. Information about rebooking may also be included in case of late arrival or cancelled flights.

3.3.10 Engine Performance Reports

Aircraft Condition Monitoring System (engine and systems) reports are down linked automatically and on request. This is usually done in the en route phase.

3.3.11 Maintenance Troubleshooting

Through this service, maintenance is able to discuss and correct technical problems while the aircraft is still airborne. Although voice is customarily used for the discussion, this service may be used to provide the instructions for problem resolution in a textual format.

3.3.12 Flight Plan Request/Flight Plan Data

This service provides the operators with the ability to request and receive the AOC-developed flight plan for comparison to that assigned by ATC and for loading into avionics. AOC flight plans have more information that flight plans filed with ATS.

3.3.13 Load Sheet Request/Load Sheet Transfer

Upon downlink request, the Load Sheet Control System uplinks planned load sheet and cargo documentation. Prior to departure, the final load sheet, including actual weight and balance data is automatically uplinked to the cockpit while the aircraft is at the gate or while waiting for takeoff. The minimum equipment list (MEL) can also be confirmed at this time.

3.3.14 Flight Log Transfer

This service delivers next flight assignment, estimated time of departure, and gate information. Flight log information may be manually requested by the flight crew or automatically uplinked.

3.3.15 Real Time Maintenance Information

This service allows aircraft parameters to be sent to the airline maintenance base in real-time to monitor the operational status of the aircraft. Information could include engine data, airframe systems, etc. This service allows information to be obtained more quickly than the normal maintenance data acquisition via on-board recorders. It is typically event driven, triggering a flow of information until resolution is achieved.

3.3.16 Graphical Weather Information

Weather information is sent to the aircraft in a form that is suitable for displaying graphically on displays in the cockpit, e.g., vector graphics. This service supplements or replaces the text weather information available in current AOC services. Graphical weather information is expected to be more strategic in nature, and will supplement on-board tactical weather radar which has inherent range and display limitations.

3.3.17 Online Technical Trouble Shooting

This service allows airline ground maintenance staff to request information from on-board systems so that a diagnosis of problems can be undertaken at locations away from the aircraft's base.

3.3.18 Real-Time Weather Reports for Met Office

Information derived by the aircraft on the environment in which it is flying (e.g., wind speed and direction, temperature) can be sent automatically in real-time to weather forecasting agencies to help improve predictions.

3.3.19 Technical Log Book Update

This service allows the flight crew to complete the aircraft's technical log electronically and send the updated log to the maintenance base. Information regarding the technical status of the aircraft can therefore be obtained much more quickly so that any remedial action can be taken at an early stage.

3.3.20 Cabin Log Book Transfer

This service allows the cabin crew to complete the aircraft's cabin equipment log electronically and send the updated log to the AOC. Information regarding the status of the cabin equipment can therefore be obtained much more quickly so that any remedial action can be taken at an early stage.

3.3.21 Update Electronic Library

The Electronic Library will replace many of the paper documents currently required to be carried in the cockpit (e.g., Aircraft Manual and AICs).   This service enables that electronic information to be updated automatically. The transmitted information will be used to update various avionic systems, e.g., an Electronic Flight Bag (EFB) device.

3.3.22 Software Loading

This service allows new versions of software to be uploaded to the aircraft systems.

4 AIRCRAFT AND AIR TRAFFIC CHARACTERISTICS

This section describes the conditions of the operating environment that are relevant to the communications loading requirements.

4.1 Air Traffic Demand

Air traffic is predicted to increase during the time period from now until 2015. In general, growth is predicted to be slightly higher during the period until 2015 than the period between 2015 and 2030. Growth is also predicted to be slightly lower in the North American region than in Europe with both regions being at or under the worldwide growth rate.

Most sources predict increases in the average number of seats per aircraft, the average load factor, and the number of hours flown. Inter-continental traffic is expected to grow at a higher rate than continental traffic. In addition, the short-term growth is predicted to be higher than the longer-term figures, as the aviation community recovers from the setbacks caused by the U.S. terrorist attacks, the SARS situation, and the Iraq war.

Traffic growth will generate the need for increased throughput on some routes, even as the creation of new routes may tend to reduce growth rates on other existing routes. New routes will be defined to accommodate new airports and associated city pairs. There may also be new routes and terminal area procedures defined for suitably equipped aircraft. Achievable throughput is dependent on traffic mix, airspace configuration, availability of controllers, and required total system performance parameters.

Sector and TMA capacity depends on airspace configuration, type of traffic involved, season/event, and time of day. Sector and TMA traffic density affects collision risk and controller workload. The availability of a 4D flight plan and the related equalization of the traffic will relax the situation.

TFM is responsible for managing future system resources, that is, the airspace and the airports. One aspect of managing these resources is to dynamically determine their capacities based on the current state of the environment. The capacity may change due to weather or other factors. Due to localized factors that influence the capacity of the various resources, it is envisioned that flow control will remain regionally focused. These capacities, however, are the basis for many of the system constraints and need to be widely available to others within the system. It is envisioned that TFM will be involved to coordinate strategically when situations involve a large number of flights or are predicted to occur some time in the future.

EUROCONTROL's Air Traffic Statistics and Forecast (STATFOR) service takes into account the factors that affect traffic and has forecast air traffic for the years 2015 through 2025. See Appendix B for a description of the STATFOR service.

4.2 Airspace Environment

Table 4-1. Airspace Environmental Characteristics (2015)

	Airport	TMA	En Route	Oceanic	Polar
Communication capability and performance	Voice is Primary for Tactical. Data is Primary for remaining communications.	Voice is Primary for Tactical. Data is Primary for remaining communications.	Voice is Primary for Tactical. Data is Primary for remaining communications.	Data communications are Primary. Third party voice or SATCOM used for non-routine and emergency communications.	Data communications are Primary. Third party voice or SATCOM used for non-routine and emergency communications.
Navigation capability and performance	Visual separation	RNAV/RNP 1	RNAV/RNP 4 RVSM	+/- 300 ft altimeter, RVSM, MNPS, Inertial +/-2 NM/hour drift rate, RNAV/RNP 10, RNAV/RNP 4	+/- 300 ft altimeter, RVSM, MNPS, Inertial +/- 2 NM/hour drift rate, RNAV/RNP 10, RNAV/RNP 4
Surveillance capability and performance	Visual and voice communication Surveillance Monitoring	ACAS Surveillance service	ACAS Surveillance service	ACAS, Time/speed-based verification, Distance-based verification, Lateral deviation monitor	ACAS, Time/speed-based verification, Distance-based verification, Lateral deviation monitor
Separation (Horizontal)	Longitudinal 2 or 3 minutes or wake turbulence criteria, whichever is greater	2.5-5 NM	5 NM	Lateral: 60 NM (MNPS), 100 NM, 50 NM, or 30 NM Longitudinal: istime-based: 5/10/15 min, Distance-based: 50 NM or 30 NM	Lateral: 100 NM, or 50 NM. Longitudinal: is time-based: 15 minutes
Separation (Vertical)	N/A	1000 ft	1000 ft RVSM	1000 ft 2000 ft RVSM	2000 ft
Traffic complexity	Complex with visual guidance	Complex route structure with complex arrival and departure routes	RNAV complex route structure	Composite separation, parallel tracks, crossing tracks	Parallel and crossing tracks.

Table 4-2. Airspace Environmental Characteristics (2030)

	Airport	TMA	En Route	Oceanic	Polar
Communication capability and performance	Data is Primary means of communications. Voice is used for non-routine, failure recovery, or emergency communications.	Data is Primary means of communications. Voice is used for non-routine, failure recovery, or emergency communications.	Data is Primary means of communications. Voice is used for non-routine, failure recovery, or emergency communications.	Data is Primary means of communications. Voice is used for non-routine, failure recovery, or emergency communications.	Data is Primary means of communications. Voice is used for non-routine, failure recovery, or emergency communications.
Navigation capability and performance	Visual separation, CDTI.	RNAV/RNP 0.5	RNAV/RNP 1 RVSM	+/- 300 ft altimeter, RVSM, MNPS, RNAV/RNP 4.	+/- 300 ft altimeter, RVSM, MNPS, RNAV/RNP 4.
Surveillance capability and performance	Visual and voice communication. Surveillance Monitoring.	Surveillance service.	Surveillance service.	Surveillance Service using ADS-B & C. ACAS. Deviation monitor.	Surveillance Service using ADS-B & C. ACAS. Deviation monitor.
Separation (Horizontal)	Longitudinal is wake turbulence criteria only.	Longitudinal is wake turbulence criteria only.	Longitudinal is wake turbulence criteria only.	Lateral: 15 NM Longitudinal: 15 NM.	Lateral: 30 NM. Longitudinal: 30 NM.
Separation (Vertical)	N/A	1000 ft	1000 ft RVSM	1000 ft RVSM	2000 ft
Traffic complexity	Complex with visual guidance	Contract based trajectories using user preferred routes with complex arrival and departure routes.	Contract based trajectories using user preferred routes.	Parallel and crossing tracks	Parallel and crossing tracks.

4.3   Aircraft Equipage

The CNS equipment required to support the operational applications is presented in the following sections. This equipment is expected to be the minimum avionics package required for FRS. It allows optional devices not in the FRS scope to be added, such as MLS or Space-Based Augmentation System (SBAS) receivers. It is understood that in the interim time period, non-FRS equipped aircraft may be operating in the airspace and will need to be accommodated. The type and mixture of equipage is unpredictable at this time.

4.3.1 Communication

An FRS aircraft is equipped for both voice communications and data link. Data communication will replace traditional voice communication for non-time-critical and large information exchanges. This measure will reduce the communication workload for the cockpit and the controller. It will increase safety because human errors caused by misinterpretation of voice messages are reduced and will decrease the problem of congestion in the VHF band. The data link exchanges may use the Aeronautical Telecommunication Network that is being deployed for this purpose.

As time progresses through the FRS lifecycle, the use of voice for ATS exchanges will evolve as well. It is anticipated that the evolution of ground automation and communications integrated with airborne automation and communication of intent data from air to ground will provide the foundation for a much more strategic management versus tactical control ATC environment. Thus, the use of voice will diminish and be used primarily for non-routine, recovery, and/or emergency communications.

4.3.2 Navigation

Procedural use of 4D navigation and guidance in the ATM system and sharing of the information will be supported in the FRS timeframe. Thus, avionics will provide navigation accuracy in 4D (lateral, longitudinal, vertical, and time) and ensure the required navigation precision. To calculate its position, the aircraft will use conventional means such as Air Data and Inertial Reference System, the ground beacons for VOR, DME, ILS, and the Global Navigation Satellite System (GNSS). Moreover, the aircraft may be equipped to receive the Ground-Based Augmentation System (GBAS) signal to be used in the GBAS Cat I approach, for example.

4.3.3 Surveillance

Primary Surveillance and Secondary Surveillance Radar, ADS-B, and ADS (Contract) will remain the basic surveillance means in the FRS timeframe. The equipment must still be compliant with independent Primary Surveillance Radar (PSR), which is required in Terminal Manoeuvring Areas (TMAs) and with the standard Mode A/C operations. The aircraft should also be equipped for the evolution of the standard SSR modes. Mode S enhanced surveillance may also be in use in parallel with FRS avionics as it will permit the aircraft to downlink other aircraft parameters via the Mode S Specific Services where these services are supported on the ground. The Automatic Dependant Surveillance-Contract (ADS) application will be provided by FRS aircraft. This application is assumed to be supported by the ATN. ADS-B is envisaged to be in use and to provide the mechanism to evolve to the airborne separation assistance system (ASAS).

4.4 Aircraft Performance

Aircraft speed and acceleration characteristics for 2015 and 2030 are provided in Table 4-3 and Table 4-4, respectively. The table values are based on the following assumptions:

- Space, and Special Use Vehicles are outside the scope of the FRS.
- Future speeds are based on the assumption that a Concorde-like aircraft may again take to flight.
- The maximum jet stream winds are 400 kph. The jet stream is applicable to enroute, oceanic, and polar domains at a ceiling of 45,000 feet.
- The maximum stratosphere winds above 45,000 feet are 200 kph.
- Winds in the TMA environment will not exceed 200 kph.
- Aircraft travel over land masses (e.g., surface, TMA, En Route) will be limited to air speeds below 1 mach (speed of sound) to prevent sonic booms, e.g., 0.95 mach.
- Maximum acceleration effects in the air are caused by turbulence (~5 G acceleration = 49 m/s^2). This will not change in the 2015 to 2030 timeframe.
- Maximum future ground acceleration (takeoff) is limited to that supported by today's aircraft tire technology (e.g., 12.5 m/s^2).
- Current maximum air speeds are based on 777 maximum speed of 0.88 mach.
- Air-Air speeds are based on the closing speed of two jet aircraft in the same wind environment.

Table 4-3. Aircraft Performance Characteristics (Current/2015)

Parameter	Surface	TMA	En Route	Oceanic	Polar
Max Gndspeed (kph)	350	1250	1450	1450	1450
Max Airspeed (kph)	350	1050	1050	1050	1050
Max Air-Air (kph)	n/a	2100	2100	2100	2100
Max Acceleration (m/s^2)	5	50	50	50	50

Table 4-4. Aircraft Performance Characteristics (2030)

Parameter	Surface	TMA	En Route	Oceanic	Polar
Max Gndspeed (kph)	450	1350	1550	2450	2450
Max Airspeed (kph)	450	1150	1150	2250	2250
Max Air-Air (kph)	n/a	2300	2300	4500	4500
Max Acceleration (m/s^2)	12.5	50	50	50	50

4.5   Aircraft Density

4.5.1   Airspace Volumes

The generic airspace types referenced in Section 4.2 are intended to represent typical airspace throughout the world. These airspace types are: airport, terminal, en route, oceanic, and polar. For each type of airspace, a typical sector volume was described. That is, the volume of airspace for that airspace type contains aircraft that are all controlled by a single controller position. In the airport domain, it equates to a cylinder of 10-mile diameter from ground to altitude of 5,000 feet. For oceanic and polar airspace, a simple model of air traffic density was used based on the number of aircraft under control of an ACC.

As these types of airspace can vary widely in their requirements depending on the level of air traffic, for each type a typical high density and low density example was also defined. Typical low and high density continental airspace types were chosen for input to the EUROCONTROL System for Traffic Assignment and Analysis at a Macroscopic Level (SAAM) tool which can simulate air traffic and provide data about the traffic through specified airspace volumes. (See Appendix B for a description of SAAM.) Although European airspace was chosen, this is believed to be typical of similar continental airspace anywhere in the world.

4.5.2   Peak Instantaneous Aircraft Count (PIAC)

Using a combination of STATFOR forecasts and the SAAM tool, the airspace model was programmed to generate unrestricted routes based on the city-pairs forecasts. In addition, peak instantaneous aircraft counts (PIACs) for the various types of airspace were predicted for the years 2015 and 2030. In each of the airspace volumes, the SAAM tool determined both the PIAC and average time spent by a flight in that airspace volume.

The PIACs for the different volumes described in Section 4.4.1 are provided in Table 4-5. The numbers derived by SAAM can be used as an indication of the communications throughput needed for these specified volumes when used in conjunction with per aircraft data rates presented in Section 7.

Table 4-5. PIACs per Sector by Domain

	Airport Density Type		TMA Density Type		En Route Density Type		Oceanic Density Type		Polar
Date	High	Low	High	Low	High	Low	High	Low	
2015	50	12	14	11	29	25	10	5	3
2030	75	19	19	14	31	30	17	9	6

Note 1: Growth factors in the continental airspace types for 2015 and 2025 are representative of the percentage growth rates produced by the SAAM Tool. Values for 2030 have been extrapolated based on a linear growth of traffic from 2025 to 2030 similar to that from 2015 – 2025.

Note 2: For the Airport numbers above, the total requirement for users needing passive access to a communications system (e.g., for monitoring) may be 200 in 2015 and 290 in 2030. In addition, surface vehicles (e.g., trucks) are not included in any numbers.

4.5.3   Transition

As with any new system being implemented into the ATC environment with the magnitude of change possible with the FRS, transition from the existing communications system should be undertaken only after careful evaluation of any human factors issues associated with differences between the two systems. To the extent possible, the FRS must have a performance at least as good as that offered by existing VHF analog systems, so that the transition is transparent for flight crews and controllers. Training in the use of new features should be undertaken in advance, such that the system aspects do not create detrimental effects on flight crew and controller performance.

5 OPERATIONAL SECURITY REQUIREMENTS

5.1 Security Applications

In the medium-to-long term future, advanced systems will make a significant contribution towards the construction of an advanced aircraft security system designed to operate during on-board terrorist threat scenarios. These will be invoked when all present security prevention measures have failed and these are considered as a last line of defense independent from ground infrastructure.

The new technology will result in an improvement of the security inside an aircraft and the ability to return the aircraft safely to the ground. The advanced aircraft security system addresses:

- Threat detection onboard the aircraft
- Threat analysis and management
- Flight protection against hostile actions
- Protection against attack on data
- Physical and information security issues and exploitation

During an act of unlawful interference, the future onboard systems will process important information which will be essential to decision making not only by the flight crew in command but also by the national civil and military authorities for any response action.

The information provided to and processed by a regional network will have elements that will be essential to the threat assessment and the decision for adequate response measures by the on board systems, flight crew in command, and national aviation authorities.

An integrated security chain needs to be established for the entire air transportation system with all parties on the ground involved in a response to a terrorist action.

1. The collection and protection of appropriate information to aid in threat and response actions throughout the event as well as any necessary post analysis of the event.

2. The output of the airborne systems on determined threat and response actions during an act of unlawful interference shall be down-linked into the Regional Network system since it might be essential to the decision makers on the ground and it is important that the information be provided to the Regional Network by means of secured communications as early as possible.

3. Prudent release of threat and analysis information to the flight crew will be determined by the regional and national aviation authorities and uplinked as necessary.

In case of incapacity of the flight crew caused by terrorists or perpetrators that have gained access to the flight controls, automated systems might be activated to prevent the use of the aircraft as a weapon.

Ultimately, this may include selection of and automatic landing at the nearest authorized airport, calculation of the new flight plan, negotiation of the flight plan with ATC and controlling all avionics systems involved in the approach procedures and the landing.

Information on the status of control of the aircraft and its predicted flight path is essential to the national authorities to take adequate measures for response and will be provided by secured communication to Regional Network.

5.2   Security of the Communications System

The exchange of airborne and ground data shall be protected against all manner of information and communication security threats including, but not limited to, threats against authentication, availability, integrity and reliability of data.

In order to protect against these threats, it is expected that security best practices will be used by the aviation community with similar updates and enhancements as experienced in other corporate environments. It is expected that information and communications security enhancements put in place for this specific threat will also be available to protect communications and information exchanges used for all other communications services.

The exchange of airborne and ground data shall be protected against:

- Unauthorized access to the information
- Denial of services/loss of ability to provide a message
- Jamming of the communication link
- Injected (malformed) messages
- Introduced erroneous information
- Deleted (components) of messages
- Altered or reordered message contents
- Impersonation of an authorized user

6   OPERATIONAL PERFORMANCE REQUIREMENTS

6.1   Introduction

From the previous discussion on requirements, this section derives the voice and data requirements against the service requirements in 2015 and 2030. This is based on an estimate of the number of voice and data exchanges in the various airspace types for both ATS and AOC.

The volume of communications is an airspace type is a function of the density of the aircraft in that airspace. Consequently, the Peak Instantaneous Aircraft Count (PIAC) (derived in Table 4-5) is an important parameter that will determine communication capacity.

6.2   Voice Performance Requirements (ATS and AOC)

Note: Performance requirements such as availability, reliability and integrity will be included in the FCOCR document.

The voice communication system must achieve the performance values in the various categories of airspace, as shown in Table 6-1.

Table 6-1. Voice Performance Requirements

	Airport	TMA	High Density En Route	Low Density En Route	Oceanic	Polar
PTT Set-up (max)	150mS	150mS	150mS	150mS	20s	20s
Latency (max)	350mS	350mS	350mS	350mS	485mS	485mS

Note: Values for the Oceanic domain in the table above are drawn from the draft ICAO AMS(R)S SARPS.

6.3   Data Performance Requirements (ATS, AOC, and ADS)

Note: Performance requirements such as availability, reliability and integrity will be included in the FCOCR document.

Using the data link services defined in Section 3, together with the PIACs in the various airspace volumes derived from SAAM, the communication requirements have been derived.

Each data link service has been associated with an airspace (e.g., ACL can be used either on the ground or en route phases) and how often it used in the airspace. QoS requirements, such as end-to-end transit times, have been assigned based on how or where the service is being used. Typically, high-density tactical airspace requires the more demanding QoSs.

The Required Communications Technical Performance (RCTP) 95 percentile Transaction Times, TT(95), for data link services supporting ATS for the airport, TMA, and en route airspace domains are shown in **Error! Reference source not found.**2. The RCTP TT(95) values for each service, Aircraft System (AS), and ATS Provider (ATSP) are based on the RTCA DO-290, continental airspace domains.

- The one-way FRS latencies were estimated by taking the two-way RCP value for different service categories from DO-290 and divided by two after allocating 4, 8, 10, or 15 seconds (95 percentile) for aircraft system processing, $TT(95)_{AS}$, and 6 seconds (95 percentile) for ground automation and network processing, $TT(95)_{GA\&N}$, e.g., for DLIC Initiation the one-way latency calculation works out to $[24-4-6]/2 = 7$ s.

Note 1: The allocation of 6 seconds for ground automation and network processing 95 percentile transaction time, $TT(95)_{GA\&N}$, was a compromise between European and US ground automation 95 percentile transaction times, $TT(95)_{GA}$, of 2 seconds and 10 seconds respectively.

Note 2: In general, 95 percentile delays are non-additive. The one-way FRS latency values derived in Table 6-2 may be conservative.

RTCA DO-290 was developed in accordance with the criteria for SPR standards set forth in RTCA DO-264/EUROCAE ED-78A, "Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by Data Communications." However, RTCA DO-290 does not consider many new services that were considered in this document. Each service in Table 6-2 was assigned one or more of the 4 communication types: emergency, tactical, strategic, and planning described in DO-264.

Table 6-2. Data Link Service and FRS RCTP 95 Percentile Delay Allocation for Airport, TMA, and En Route Domains

(Based on RTCA DO-290 SPR)

Service	Commu-nication Type	Function	RCTP TT(95)$_{Service}$ (secs)	RCTP TT(95)$_{AS}$ (secs)	RCTP TT(95)$_{ATSP}$ (secs)	RCTP TT(95)$_{FRS}$ (secs)	One-way FRS Latency (95%) (secs)
Data Link Initiation Capability (DLIC)	Strategic	Initiation	24	4	20	14	7
		Contact	48	8	40	28	14
		Update	Undefined	Undefined	Undefined	Undefined	Undefined
ATC Communication Management (ACM)	Strategic	All	16	4	12	6	3
ATC Clearance (ACL)	Tactical, Strategic	Flight crew initiated	16	4	12	6	3
		Controller initiated	16	4	12	6	3
ATC Microphone Check (AMC)	Tactical	Controller initiated	Undefined	Undefined	Undefined	Undefined	Undefined
Departure Clearance (DCL)	Strategic	Flight crew initiated	40	10	30	24	12
		Controller initiated	40	10	30	24	12
Downstream Clearance (DSC)	Planning	Flight crew initiated	100	10	90	84	42
Digital Automatic Terminal Information (D-ATIS)	Strategic Planning	Flight crew initiated	20	8	12	6	3
Flight Plan Consistency (FLIPCY)	Planning	Ground initiated	60	15	45	39	19.5

Note1: RCTP TT(95)$_{Service}$ are two-way 95% delays between controller and flight crew including ground automation, ground networks, the FRS, and aircraft system delays.

TT(95)$_{ATSP}$ = TT(95)$_{Service}$ - TT(95)$_{AS}$ where AS = Aircraft System

TT(95)$_{FRS}$ = TT(95)$_{Service}$ - TT(95)$_{AS}$ – TT(95)$_{GA\&N}$, where GA & N = Ground Automation & networks

Note 2: RCTP TT(95)$_{Service}$ for DLIC Contact involves 2 transactions, the one-way TT(95)$_{FRS}$ is for 2 transactions.

Note 3:   One-way service environments including DLIC Update and AMC Controller Initiated do not have defined values in DO-290.

Table 6-3 summarizes the derived FRS one-way TT(95) values from Table 6-2 for the various service types for the continental airspace, which showed that the emergency service type has no defined value and some service types have more than 1 value. For consistency and to consider those services not defined in DO-290 a single value was assigned to each service type in Table 6-3 and applied to the ATS data loading tables in Section 7. These values will be revisited for the FCOCR.

Table 6-3. Derived and Assigned FRS One-Way TT(95) Service Type Values for Continental Airspace

Service Type	Derived one-way TT(95)$_{FRS}$ from Table 6-2 (seconds)	Assigned one-way TT(95)$_{FRS}$ (seconds)
Emergency	Undefined	1.5
Tactical	3	3
Strategic	3, 7,12	7
Planning	3, 19.5, 42	40

The FRS TT(95) results for the Oceanic and Polar airspace domains are shown in Table 6-4. For these two airspaces, standards equivalent to DO-290 are still being drafted; therefore for the ICOCR, the TT(95) numbers were estimated based on RTCA DO-284, Appendix C1. Emergency and tactical messages are usually not used in these domains given the latency of communications technology in these domains.

Table 6-4. One-Way Communications Latency (95 Percentile, TT(95)) for Oceanic and Polar Domains

Message Type	Oceanic	Polar
Emergency	n/a	n/a
Tactical	n/a	n/a
Strategic	8.5 s	8.5 s
Planning	180 s	180 s

ADS-B was considered separately and assumed to broadcast one message every second in each domain.

7 COMMUNICATION LOADING ANALYSIS

In this section, the performance requirements of the FRS are determined taking into account the operational requirements for safety and regularity of flight communications identified in the previous sections. ATS and AOC voice and data requirements are derived. These estimates are based on previous studies conducted in the United States and Europe and have been modified as needed by ATM subject matter experts. The main references for ATM services were the FAA DLORT study, EUROCONTROL CASCADE program requirements, and various RTCA reference documents.

The communication performance requirements are defined for the various airspace types defined in Section 4.

- Airport
- Terminal
- En Route
- Oceanic
- Polar

7.1 Voice Loading Analysis

Note: The Voice Loading Analysis will be provided in the FCOCR. The following paragraphs present the intended analytical approach.

The COCR team intends to adopt the bottom-up structural approach used to perform the data analysis. The number of instances of voice transactions for each applicable service type will be estimated by flight phase. This approach will allow a more direct comparison of voice and data loading analyses. As a check and balance, the resulting occupancies will be compared with empirical channel occupancy rates.

The loading table values will use seconds per aircraft per domain rather than bps per aircraft per domain (as is done in the data loading approach). This will more easily allow the evaluation and impact of different voice compression technologies (an example bps calculation will be provided for at least one vocoder implementation).

The seconds will be calculated by multiplying the number of instances per domain by the average contact duration. Empirical data (e.g., VOCALISE project) will be used to determine the average contact duration for each airspace type. Only the active occupancy time will be used in the contact duration, i.e., the human response time in the request/reply transaction will not be included. It is assumed that the FRS solution could make use of this time to transmit other information rather than silence.

In addition to the table types for the 2015 and 2030 periods, it is anticipated that two voice cases will be evaluated. The first voice case will be the worst-case voice situation. For this situation, it is assumed that minimal/no data link capability is implemented. The second voice case will be the allocated-case voice situation. For this situation, it is assumed that the voice instances would complement the data instances in the data loading analysis.

Evaluating the worst-case may provide insight on communication loading for regions that are not fully data link capable as well as insight into temporary loading situations due to technology transition. Further, this case may need to be considered if voice is to provide a full-backup to data link operations. Evaluating the allocated-case should provide insight into the communication loading for the 'final' state.

7.1.1   Voice Assumptions

Note: Voice analysis assumptions will be provided in the FCOCR document.

7.1.2   Voice Traffic

Note: Voice analysis assumptions will be provided in the FCOCR document.

7.2   Data Loading Analysis

Note: Under development.

7.2.1   Data Assumptions

Note: The FCOCR will add a more complete description of the process to obtain throughput values derived in the tables for data.

For the ADS-B service, it was assumed that each aircraft will emit one message per second. The total number of messages sent per aircraft in a particular domain depends on the flight time through that domain. These are summarized in Table 7-1.

Table 7-1. Average Flight Time by Domain

Date	Airport	TMA	En Route	Oceanic	Polar
2015	600s	420s	1500s	10800s	10800s
2030	600s	420s	1500s	10800s	10800s

Note 1: These 2030 numbers will be revisited in the FCOCR

Note 2: For AOC services, the message size and instances were primarily derived from [5]. Delivery times are based on the 90 second delay provided in [5]; however, some services have reduced delay requirements. The Gate and Connecting Flight service is not described in [5]; thus, values for this service are estimated. The Graphical Weather Information service message size was increased from 2000 to 8000 bytes to encompass compressed bitmapped graphics with increased resolution. In addition, there are some differences in the Position Report and Flight Status service from that characterized in [5]. In this document, the Position Report service is used frequently and has a smaller message size; thus, the values provided in Table 7-2 for these two services have been changed accordingly. Finally, the Update Electronic Library service data requirements for 2030 have been substantially increased.

7.2.2 Data Traffic

The total data traffic generated per aircraft for safety and regularity of flight communications is summarised in Table 7-2.

For each message type, the estimated size of the uplink and downlink messages are calculated or estimated. Figures for message size are based on typical Application Protocol Data Units (APDUs). With the overhead of the ATN added (Ref 12). The values are therefore the size of the message as presented to the FRS interface.

Table 7-2. 2015 ATS Data Loading Table

ATS	Uplink (bytes)	Downlink (bytes)	Total	Airport			TMA			EN ROUTE			OCEANIC			POLAR		
				Instances	95% end-to-end, secs	Msg bytes/sec/aircarft	Instances	95% end-to-end, secs	Msg bytes/sec/air craft	Instances	95% end-to-end, secs	Msg bytes/sec/air craft	Instances	95% end-to-end, secs	Msg bytes/sec/air craft	Instances	95% end-to-end, secs	Msg bytes/sec/air craft
ACL (slow)	260	250	510	1	7	37	0	-	0	3	7	37	2	8.5	31	1	8.5	31
ACL (fast)	260	250	510	0	-	0	2	3	87	2	3	87	0	-	0	0	-	0
ACM	390	332	722	3	7	56	1	7	56	1	7	56	1	8.5	46	1	8.5	46
ACPDLC	INC IN ACL, ACM, etc			0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
ALERT	260	1000	1260	0	-	0	0	-	0	1/yr	1.5	667	0	-	0	0	-	0
AMC	260	250	510	0	-	0	1	3	87	1	3	87	0	-	0	0	-	0
ARMAND	260	250	510	0	-	0	1	40	7	1	40	7	0	-	0	0	-	0
D-ATIS (Departure)	288	181	469	1	40	7	0	-	0	0	-	0	0	-	0	0	-	0
D-ATIS (Arrival)	471	262	733	0	-	0	1	7	67	1	7	67	0	-	0	0	-	0
C&P	260	250	510	0	-	0	0	-	0	1	7	37	0	-	0	0	-	0
SAP (Periodic contract)	184	833	1017	0	-	0	2	40	21	2	40	21	0	-	0	0	-	0
DCL	278	249	527	1	7	40	0	-	0	0	-	0	0	-	0	0	-	0
DLIC / DLL	228	253	481	1	7	36	0	-	0	1	7	36	1	8.5	30	1	8.5	30
DSC	300	250	550	0	-	0	0	-	0	1	40	8	1	180	2	1	180	2
DYNAV	1000	1000	2000	0	-	0	0	-	0	1	7	143	0	-	0	0	-	0
FLIPCY	200	1900	2100	1	40	48	1	40	48	1	40	48	1	180	11	1	180	11
FLIPINT (ADS-C Position Rpts)	1000	1000	2000	0	-	0	1	40	25	1	40	25	6	180	6	6	180	6
FLUP	1700	250	1950	1	7	243	1	7	243	1	7	243	0	-	0	0	-	0
GRECO	400	400	800	0	-	0	0	-	0	1	40	10	0	-	0	0	-	0
ITP	300	250	550	0	-	0	0	-	0	0	-	0	1	8.5	35	1	8.5	35
D-ORIS	1800	250	2050	0	-	0	0	-	0	1	40	45	0	-	0	0	-	0
D-OTIS	1800	250	2050	1	7	257	1	7	257	0	-	0	0	-	0	0	-	0
PPD	300	900	1200	1	40	23	1	40	23	1	40	23	0	-	0	0	-	0
RVR	300	250	550	1	3	100	1	3	100	1	3	100	0	-	0	0	-	0
S&M	260	250	510	0	-	0	1	3	87	1	3	87	0	-	0	0	-	0
D-SIGMET	1600	0	1600	1	7	229	1	7	229	1	7	229	1	8.5	188	1	8.5	188
D-SIG	3000	0	3000	1	40	75	0	-	0	0	-	0	0	-	0	0	-	0
D-TAXI	400	0	400	1	7	57	0	-	0	0	-	0	0	-	0	0	-	0
URCO	250	250	500	0	-	0	0	-	0	1	1.5	167	0	-	0	0	-	0
ATSAW/ASAS (ADS-B)		372	372	600	1	372	420	1	372	1500	1	372	10800	1	372	10800	1	372

Table 7-3. 2015 AOC Data Loading Table

AOC	Uplink (bytes)	Downlink (bytes)	Total	Airport			TMA			EN ROUTE			OCEANIC			POLAR		
				Instances	95% end-to-end, secs	Msg bytes/sec/aircarft	Instances	95% end-to-end, secs	Msg bytes/sec/aircraft	Instances	95% end-to-end, secs	Msg bytes/sec/aircraft	Instances	95% end-to-end, secs	Msg bytes/sec/aircraft	Instances	95% end-to-end, secs	Msg bytes/sec/aircraft
AOC	Overhead	40																
Out/Off/On/IN (OOOI)	0	80	80	4	90	1		90	0	0		0		-	0		-	0
NOTAM Request/NOTAM	316	142	458	1	90	4		90	0	1	90	4		-	0			0
Free Text	336	336	672	0	90	0	0	90	0	1	90	4	1	90	4	1	90	4
Weather	120	120	240	1	90	1	0	90	0	1	90	1	1	90	1	1	90	1
Flight Status	0	301	301	0	90	0	0	90	0	1	90	3	1	90	3	1	90	3
Loadsheet/Request Transfer	120	120	240	1	8.5	14	0	8.5	0	0	8.5	0		8.5	0		8.5	0
Position Report	120	120	240	1	90	1	2	90	1	2	90	1	2	90	1	2	90	1
Fuel Status	80	80	160	0	90	0	0	90	0	2	90	1	2	90	1	2	90	1
Engine Performance Reports	140	140	280	0	90	0	3	90	2	1	90	2	1	90	2	1	90	2
Maintenance Report	90	140	230	0	90	0	0	90	0	1	90	2	1	90	2	1	90	2
Flight Plan Transfer	240	90	330	0	90	0	1	90	3	1	90	3	1	90	3	1	90	3
Flight Log Transfer	90	140	230	1	90	2	1	90	2	0	90	0		90	0		90	0
Gate & Connecting Flight Status	440	0	440	0	90	0	1	90	5	0	90	0		90	0		90	0
Real Time Maintenance Information	90	90	180	0	8.5	0	0	8.5	0	5	8.5	11	5	8.5	11	5	8.5	11
Graphical Weather Information	8040	90	8130	1	90	89	0	90	0	4	90	89	4	90	89	4	90	89
Real Time Weather Reports	0	66	66	0	90	0	7	90	1	25	90	1	25	90	1	25	90	1
Technical Log Book Update	0	440	440	1	90	5	0	90	0	0	90	0	0	90	0	0	90	0
Cabin Log Book Update	0	440	440	1	90	5	0	90	0	0	90	0	0	90	0	0	90	0
Onboard Documentation Trans	1040	0	1040	1	90	12	0	90	0	0	90	0		90	0		90	0
Online Technical Trouble Shoot	540	540	1080	0	8.5	0	0	8.5	0	5	8.5	64	5	8.5	64	5	8.5	64
Software Loading	4040	0	4040	1	180	22	0	180	0	0	180	0		180	0		180	0

Table 7-4. 2030 ATS Data Loading Table

ATS	Uplink (bytes)	Downlink (bytes)	Total	Airport			TMA			EN ROUTE			OCEANIC			POLAR		
				Instances	95% end-to-end, secs	Msg bytes/sec/aircarft	Instances	95% end-to-end, secs	Msg bytes/sec/aircraft	Instances	95% end-to-end, secs	Msg bytes/sec/craft	Instances	95% end-to-end, secs	Msg bytes/sec/aircraft	Instances	95% end-to-end, secs	Msg bytes/sec/craft
ACL (slow)	260	250	510	2	7	37	0	-	0	0	-	0	0	-	0	0	-	0
ACL (fast)	260	250	510	0	-	0	3	3	87	3	3	87	0	-	0	0	-	0
ACM	390	332	722	3	7	56	1	7	56	1	7	56	1	8.5	46	1	8.5	46
ACPDLC	INC IN ACL, ACM, etc			0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
ALERT	260	1000	1260	0	-	0	0	-	0	1/yr	1.5	667	0	-	0	0	-	0
AMC	260	250	510	0	-	0	1	3	87	1	3	87	0	-	0	0	-	0
ARMAND	260	250	510	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
D-ATIS (Departure)	288	181	469	1	40	7	0	-	0	0	-	0	0	-	0	0	-	0
D-ATIS (Arrival)	471	262	733	0	-	0	1	7	67	1	7	67	0	-	0	0	-	0
C&P	260	250	510	0	-	0	0	-	0	1	7	37	1	8.5	31	0	-	0
SAP (Periodic contract)	184	833	1017	0	-	0	30	3	278	30	3	278	0	-	0	0	-	0
DCL	278	249	527	1	7	40	0	-	0	0	-	0	0	-	0	0	-	0
DLIC / DLL	228	253	481	1	7	36	0	-	0	0	-	0	0	-	0	0	-	0
DSC	300	250	550	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
DYNAV	1000	1000	2000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
FLIPCY	200	1900	2100	1	40	48	1	40	48	1	40	48	1	180	11	1	180	11
FLIPINT (ADS-C Position Rpts)	1000	1000	2000	0	-	0	1	40	25	1	40	25	1	180	6	1	180	6
FLUP	1700	250	1950	1	7	243	0	-	0	1	7	243	0	-	0	0	-	0
GRECO	400	400	800	0	-	0	0	-	0	0	-	0	2	180	2	0	-	0
COTRAC	3000	3000	6000	1	40			-		1	40		1			1		
ITP	300	250	550	0	-	0	0	-	0	0	-	0	1	8.5	35	1	8.5	35
D-ORIS	1800	250	2050	0	-	0	0	-	0	1	40	45	0	-	0	0	-	0
D-OTIS	1800	250	2050	1	7	257	1	7	257	1	7	257	0	-	0	0	-	0
PPD	300	900	1200	1	40	23	1	40	23	1	40	23	0	-	0	0	-	0
D-RVR	300	250	550	1	3	100	1	3	100	1	3	100	0	-	0	0	-	0
S&M	260	250	510	0	-	0	1	3	87	1	3	87	0	-	0	0	-	0
D-SIGMET	1600	0	1600	1	7	229	1	7	229	1	7	229	1	8.5	188	1	8.5	188
D-SIG	3000	0	3000	1	40	75	0	-	0	0	-	0	0	-	0	0	-	0
D-TAXI	400	0	400	1	7	57	0	-	0	0	-	0	0	-	0	0	-	0
URCO	250	250	500	0	-	0	0	-	0	1	1.5	167	0	-	0	0	-	0
ATSAW/ASAS (ADS-B)		372	372	900	1	372	492	1	372	1800	1	372	10800	1	372	10800	1	372

Table 7-5. 2030 AOC Data Loading Table

AOC	Uplink (bytes)	Downlink (bytes)	Total	Airport			TMA			EN ROUTE			OCEANIC			POLAR		
				Instances	95% end-to-end, secs	Msg bytes/sec/aircarft	Instances	95% end-to-end, secs	Msg bytes/sec/craft	Instances	95% end-to-end, secs	Msg bytes/sec/craft	Instances	95% end-to-end, secs	Msg bytes/sec/craft	Instances	95% end-to-end, secs	Msg bytes/sec/craft
AOC	Overhead	40																
Out/Off/On/IN (OOOI)	0	80	80	4	90	1		90	0	0		0		-	0		-	0
NOTAM Request/NOTAM	316	142	458	1	90	4		90	0	1	90	4		-	0			0
Free Text	336	336	672	0	90	0	0	90	0	1	90	4	1	90	4	1	90	4
Weather	120	120	240	1	90	1	0	90	0	1	90	1	1	90	1	1	90	1
Position Report	0	301	301	0	90	0	0	90	0	1	90	3	1	90	3	1	90	3
Loadsheet/Request Transfer	120	120	240	1	8.5	14	0	8.5	0	0	8.5	0		8.5	0		8.5	0
Flight Status	120	120	240	2	90	1	2	90	1	2	90	1	2	90	1	2	90	1
Fuel Status	80	80	160	0	90	0	0	90	0	2	90	1	2	90	1	2	90	1
Engine Performance Reports	140	140	280	0	90	0	3	90	2	1	90	2	1	90	2	1	90	2
Maintenance Report	90	140	230	0	90	0	0	90	0	1	90	2	1	90	2	1	90	2
Flight Plan Transfer	240	90	330	0	90	0	1	90	3	1	90	3	1	90	3	1	90	3
Flight Log Transfer	90	140	230	1	90	2	1	90	2	0	90	0		90	0		90	0
Gate & Connecting Flight Status	440	0	440	0	90	0	1	90	5	0	90	0		90	0		90	0
Real Time Maintenance Information	90	90	180	0	8.5	0	0	8.5	0	5	8.5	11	5	8.5	11	5	8.5	11
Graphical Weather Information	8040	90	8130	1	90	89	0	90	0	4	90	89	4	90	89	4	90	89
Real Time Weather Reports	0	66	66	0	90	0	7	90	1	25	90	1	25	90	1	25	90	1
Technical Log Book Update	0	440	440	1	90	5	0	90	0	0	90	0	0	90	0	0	90	0
Cabin Log Book Update	0	440	440	1	90	5	0	90	0	0	90	0	0	90	0	0	90	0
Onboard Documentation Trans	50000	0	50000	1	90	556	0	90	0	0	90	0		90	0		90	0
Online Technical Trouble Shoot	540	540	1080	0	8.5	0	0	8.5	0	5	8.5	64	5	8.5	64	5	8.5	64
Software Loading	4040	0	4040	1	180	22	0	180	0	0	180	0		180	0		180	0

7.3   Loading Analysis Limitations

Table 7-1, average flight time per domain, represents the time to fly through an ACC (facility) that controls airspace of that domain type.

Data rates per aircraft in Table 7-2 reflect the number of instances of occurrence of a given service in a typical sector/position in that type of airspace in a trans-oceanic flight. The instances only count the outbound portion of the flight to the Oceanic/Polar domain. It is assumed that the number of instances as the aircraft returns to the en route, TMA, etc., are balanced. The FRS is only supporting the aircraft once in any type of airspace at any given instance.

PIACs represent the amount of aircraft associated with one sector/position at a given instance in time in that type of airspace.

8   SUMMARY

8.1   Scope

The scope of the ICOCR covers all air/ground and air/air operational services including ADS-B type and future AOC services.

8.2   Approach

In carrying out this ICOCR, a requirement driven approach was taken.

The first step was to review the expected operational concepts in the period in which a future communication system will be used, i.e., starting in 2015 with a lifetime of at least 15 years.   The starting date of 2015 was chosen as the date at which a new communication system was required to start operation to complement the existing communication system in the high density areas of the world where deficiency in communication capability will be a major limitation to airspace capacity.   However a fundamental goal of the ICOCR is to take into account requirements and solutions relevant to all regions of the world.

The operational concepts relating to the scope of the ICOCR, i.e., safety and regularity of flight communications, were drawn from the ICAO and regional implementation plans in the United States and Europe.

As an aid to comprehension of the operational concepts, example scenarios in 2015 and 2030 illustrate how communication is being used for ATS and AOC applications.   For each time frame, a set of generic operational services were identified, many of which could be supported by voice or data link; some are only able to be supported by data link.

Having identified the concepts and underlying service requirements, the amount of communication traffic generated in representative operational volumes was then calculated.   As part of this process, it was decided to define volumes of airspace in which the services were required.   Airspace types used were airport, TMA, en route (continental), oceanic, and polar.   Definitions of these airspace types are given in the document.

Using a EUROCONTROL model of air traffic growth (SAAM) for 2015 and 2025, peak instantaneous aircraft counts (PIACs) for the business day in those years were calculated. In addition, the average time in that volume was calculated.

The data communication traffic was estimated based on the size of the data exchanges taking into account typical message size, end-to-end technical delay allowable, ATN overhead, and instances of exchange of the messages in the various airspace volumes.

The intention was then to combine communication traffic generated and PIAC to get an estimate of the size of a communication system to support that traffic load in each airspace volume. Also, it was intended to identify the peak communication requirement to dimension the peak capability needed. A worst-case calculation, based on multiplying all the factors, produced a result that was clearly unrealistic. Other methods of identifying the peak requirements for a set of simultaneously pending messages was also tried, but it was not possible to agree on a representative set. A traffic model-based approach was felt to offer the best approach to calculating at least an average value. However, in the time available it was not possible to apply a representative traffic model and, therefore, this aspect will be pursued in the FCOCR. It was obvious from the figures already obtained that ADS-B requirements and some future AOC applications are likely to dominate the communication traffic and will be a major factor in determining the FRS.

Throughout the period covered in the ICOCR voice communication was considered to be available at all times. It was assumed that the performance of the FRS should be the same as the existing analog technology and the amount of traffic would vary depending on the airspace and timeframe. The general trend is that voice will become confined to airspace where tactical ATM is required, e.g., TMA.

8.3   Summary of the Operational Concept and Trends

In general, it has been determined that voice will continue to be the main executive method at the start of the timeframe with a gradual shift to data link based operation.

More automation will be introduced to enable ATM to move towards a strategic environment. Greater integration between the aircraft systems and the ground automation will allow the airspace user more efficient flight profile such as negotiation based on 4D-trajectory information. This will require a greater information flow between the aircraft and the ground. ADS-B type systems will be used by other adjacent aircraft for more ASAS type applications.

More information will be exchanged between all stakeholders through an environment that supports Collaborative Decision-Making (CDM). Some of this information will take place over the air/ground communication system by means of those services identified in section three. These requirements have been taken into account to some extent but further work is needed.

8.4   Areas for Future Work

In completing the ICOCR, a number of issues were identified that require further investigation. These will be undertaken in completing the final version of the document—the Final Communications Operation. These include:

1. Complete performance requirements for voice service and data.

2. To validate the PIAC values obtained from the EUROCONTROL SAAM tool by comparison with results from other regions of the world, e.g., the United States, using the MITRE Mid Level Model (MLM).

3. Confirmation that there is no requirement for a selective voice addressing for ATS or AOC.

4. Confirm requirements for party line voice service.

5. Refine assumptions on allocation between voice and data services.

6. Develop generic high-level operational safety requirements.

7. Incorporate projected equipage rates and implications of mixed equipage.

8. Investigate oceanic/polar surveillance service (and its use of ADS message exchanges).

9. Consideration of the level of operational security requirements for the communications system.

10. Introduction of Joint Planning and Development Office (JPDO) concepts.

11. Confirm the impact of TIS-B on the FRS performance as appropriate.

8.5   Areas for Consultation

The following specific areas have been identified for consultation with stakeholders

1. Confirm that requirements and process take into account other regions of the world.

2. It has been difficult to get information on the requirements for AOC concepts in the timeframe of 2030. Airspace user input is sought.

3. Clarification on the requirement for two-way air/air data exchange.

4. Will the FRS be the same link as used for security operational services?

5. Consult with the military user regarding how their systems fit these concepts.

APPENDICES

A ACRONYMS and ABBREVIATIONS

3D	Three Dimensional (longitude, latitude, and altitude)
4D	Four Dimensional (latitude, longitude, altitude, and time)
ACAS	Aircraft Collision Avoidance System
ACC	Area Control Center
ACM	ATC Communications Management
ACMS	Aircraft Condition Monitoring System
ADAP	Automated Downlink of Airborne Parameters
ADS	Automatic Dependent Surveillance (Contract)
ADS-B	Automatic Dependent Surveillance – Broadcast
AEEC	Airlines Electronic Engineering Committee
AGDL	Air/Ground Data Link
AIC	Aeronautical Information Circular
AMAN	Arrival Manager
AMC	Airspace Management Cell
AMC	ATC Microphone Check
AMN	Airspace Management and Navigation
AM(R)S	Aeronautical Mobile (Route) Service
AMS(R)S	Aeronautical Mobile Satellite (Route) Service
ANSP	Air Navigation Service Provider
AO	Airline Operations
AOC	Aeronautical Operational Control
AP	Action Plan
APP	Approach Control
ARMAND	Arrival Manager Information Delivery Service
AS	Airborne Surveillance
ASAS	Airborne Separation Assistance System
A-SMGCS	Advanced-Surface Movement Guidance and Control System
ASPA	Airborne Spacing
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATFM	Air Traffic Flow Management
ATIS	Automatic Terminal Information Service
ATM	Air Traffic Management
ATN	Aeronautical Telecommunication Network
ATS	Air Traffic Services
ATSA	Airborne Traffic Situational Awareness
ATSU	ATS Unit
bps	bits per second
Bps	Bytes per second
CASCADE	Cooperative ATS through Surveillance and Communication Applications Deployed in ECAC

C-ATSU	Controlling ATSU
CDM	Collaborative Decision Making
CDTI	Cockpit Display of Traffic Information
CFMU	Central Flow Management Unit
CNS	Communication, Navigation and Surveillance
COTRAC	Common Trajectory Coordination
CTOT	Calculated Takeoff Time
CWP	Controller Working Position
D-ATIS	Data Link ATIS
D-ATSU	Down Stream ATSU
DCL	Departure Clearance
D-FLUP	Data Link Flight Update Service
DLL	Data Link Logon
DLORT	Data Link Operational Requirements Team
DMAN	Departure Manager
DME	Distance Measuring Equipment
D-ORIS	Data Link Operational En-Route Information Service
D-OTIS	Data Link Operational Terminal Information Service
D-RVR	Data Link Runway Visual Range
DSB-AM	double side band - amplitude modulation
DSC	Down Stream Clearance
D-SIG	Data Link Surface Information and Guidance
D-SIGMET	Data Link Significant Meteorological Information
D-TAXI	Data Link Taxi Clearance Delivery
DYNAV	Dynamic Route Availability
EASA	European Aviation Safety Agency
ECAC	European Civil Aviation Conference
EFB	Electronic Flight Bag
EICAS	Engine Indicating and Crew Alerting System
EMER	Emergency
ETD	Estimated Time of Departure
EUROCAE	European Organization for Civil Aviation Equipment
FAA	Federal Aviation Administration
FCOCR	Final Communications Operating Concepts and Requirements
FCS	Future Communications Study
FRS	Future Radio System
FDPS	Flight Data Processing System
FIS	Flight Information Service
FLIPCY	Flight Plan Consistency
FLIPINT	Flight Path Intent
FM	frequency modulation
FMP	Flight Management Position
FMS	Flight Management System
FPL	Flight Plan
FUA	Flexible Use of Airspace

GA	general aviation
GBAS	Ground-Based Augmentation System
GIS	Geographical Information System
GNSS	Global Navigation Satellite System
GRECO	Graphical Enabler for Graphical Coordination
GS	Ground Surveillance
HF	high frequency
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICOCR	Initial Communications Operating Concepts and Requirements
IFPS	Initial Flight Plan Processing System
ILS	Instrument Landing System
ITP	In Trail Procedure
ITU	International Telecommunication Union
JPDO	Joint Planning and Development Organization
Kbps	kiloBytes per second
kHz	kilo-Hertz
kph	kilometers per hour
MASPS	Minimum Aviation System Performance Standards
mE	milli-Erlangs
MEL	Minimum Equipment List
METAR	Meteorological Aerodrome Report
MHz	mega-Hertz
MLS	Microwave Landing System
MNPS	Minimum Navigation Performance Specification
MOS	Mean Opinion Score
m/s^2	meters per second squared
ms	milliseconds
MTCD	Medium Term Conflict Detection
NM	nautical mile
NOP	Network Operations Plan
NOTAM	Notice to Airmen
OCD	Operational Concept Document
OOOI	Out-Off-On-In
PIAC	peak instantaneous aircraft count
PIB	Pre-flight Information Bulletin
PIREP	flight crew Report
PLAN	Planning
PPD	flight crew Preferences Downlink
PSR	Primary Surveillance Radar

QoS	Quality of Service
RCP	Required Communication Performance
RCTP	Required Communication Technical Performance
RNAV	Area Navigation
RNP	Required Navigation Performance
ROA	Remotely operated aircraft
RTA	Required Time of Arrival
RTCA	RTCA, Inc.
RVR	Runway Visual Range
RVSM	Reduced Vertical Separation Minima
s	seconds
SAAM	System for Assignment and Analysis at a Macroscopic Level
SAP	System Access Parameters
SARPS	Standards and Recommended Practices
SARS	Severe Acute Respiratory Syndrome
SATCOM	Satellite Communications
SBAS	Space-Based Augmentation System
SC	Special Committee
SID	Standard Instrument Departure
SPR	Safety and Performance Requirements
SRS	Standard Routing Scheme
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival Route
STATFOR	Statistics and Forecast Service
STRAT	Strategic
SUV	Special Use Vehicles
TAC	Tactical
TAF	Terminal Area Forecast
TBS	To be supplied
TFM	Traffic Flow Management
TIS-B	Traffic Information Service – Broadcast
TMA	Terminal Maneuvering Area
TOD	Top of Descent
TWR	Tower Control
UAV	Unmanned Aerial Vehicle
UPT	User Preferred Trajectory
U.S.	United States
VHF	very high frequency (108 – 137 MHz)
VOR	VHF Onmidirectional Range
VTOL	vertical takeoff and landing
WRC	World Radio Conference

B STATFOR and SAAM OVERVIEW

B.1. Description of the Air Traffic Statistics and Forecast Service

The Air Traffic Statistics and Forecast (STATFOR) service was established by the EUROCONTROL Agency and has been active since 1967. The objective of the STATFOR service is to provide statistics and forecasts on air traffic in Europe and to monitor and analyse the evolution of the Air Transport Industry.

The STATFOR service of statistics and forecasts is discussed and reviewed by the STATFOR User Group, a body of European forecasting and statistics experts that meets regularly. The terms of reference of the User Group include methodological and practical aspects of statistics and forecasting as well as an exchange of views and information on the current and possible future situation of air traffic, and on activities in National Administrations, International Organizations and elsewhere in the field of statistics and forecasting.

Currently, STATFOR's two main products are monthly statistics, and an annual medium-term forecast.

B.2. Description of the System for Traffic Assignment and Analysis at a Macroscopic Level (SAAM)

SAAM is an integrated system for wide or local design evaluation, analysis, and presentation of Air Traffic Airspace/TMA scenarios.

B.2.1 Background

EUROCONTROL develops and operates a set of tools in order to assess quantitative information in support of development at Europe's airports, on air routes and the airspace system. SAAM is being used in the context of Airspace Management and Navigation activities to perform strategic traffic flow organisation, route network and airspace optimisation, analysis and presentation. These features support the development of the EUROCONTROL Airspace Strategy for the ECAC states.

SAAM can operate on an area the size of ECAC or at the detailed level of an airport, and is able to process a large quantity of data: hundreds of sectors, millions of cells, several days of traffic. It can be used for preliminary surveys, for testing and analysing various options and for preparing a scenario that can be exported to fast-time or real-time simulators. Its powerful "what if" functions associated with presentational capabilities make SAAM an ideal tool for understanding, experimenting, evaluating and presenting European Airspace proposals and future ATC concepts.

B.2.2 Modeling

Airspace structure design and the processing of traffic trajectories are fully mastered and linked together in SAAM. Users can create/change/design both air traffic route networks and airspace volumes. At any time full 4D trajectories can be generated (based on traffic demand, route network, aircraft performance) and intersected with airspace volumes. By default, SAAM will choose the best trajectory option (shortest path and optimal profile performance), but operational rules can be applied such as flight level constraints (arrival, departure, cruising) and/or reserved or restricted route network segments.

In order to help optimise airspace structures, the user can request the traffic demand be optimally and automatically distributed on the structure at the lowest cost, while respecting operational rules, thus revealing structural weaknesses of airspace areas. This function makes use of advanced linear programming techniques, embedded in the SOP model and developed in the EUROCONTROL AMN Unit. SIDs and STARs can be portrayed for different cases, possibly with terrain data to help understand and improve TMA organization.

B.2.3 Analysis

Different sources of data can be selected for analysis and comparisons: CFMU flight plan, imported radar data, or simply the data coming out from the SAAM modelling tools.

Many queries can be combined and applied on the 4D traffic trajectories. For instance, the user can request flight trajectories based on departures, arrivals, route points, companies, sectors crossed, aircraft type, etc.

Various analyses can be performed on loaded airspace structures. The number of flights on route network points, route network segments, airspace volume and 3D density cells can be filtered and displayed accordingly. Graphs showing variations and comparisons of airspace load, entry rate, and conflict, for each hour of the day are easily produced. In the same manner, controller workload graphs can be provided rapidly using a validated analytical formula. Capacity figures for newly designed sectors can be advantageously derived using the analytical formulas.

Route length extension, fuel consumption, delays, route charges, etc., can be launched independently, and results can be summarized and mixed to give a global economic indicator of a scenario.

B.2.4 Visualization/Presentation

The importance of visually pinpointing problems and graphically presenting possible solutions was recognised from the beginning. Therefore, SAAM is entirely built on a

2D/3D/4D Geographical Information System (GIS) with the possibility of generating time based animations. To add more realism, SAAM can also manage and generate stereo information (with specific hardware-like stereo glasses).

All modelling and analysis activities are integrated in this GIS platform and fully benefit from the 3D visualisation, animation and stereo. For instance a user can design a specific airspace of interest in 3D to check interaction while aircraft are flying on their 3D trajectories. Images/animations are interactively panned, zoomed, and rotated with the mouse. The camera location and/or "look at" point can be moved or linked to a flying object.

Objects such as aircraft, airspace volumes, points or lines, can be moved, set on/off, or have their graphical attributes (e.g., color or size) smoothly changed based on time events managed through the animations. For example, this feature is commonly used to demonstrate the benefits of Flexible Use of Airspace project (FUA). Several 3D aircraft models are available and can be imported from the classical "3ds" format.

Users can add titles and bitmaps to their design. Pictures/animations can be grouped into a SAAM presentation file that can be run manually or in standalone mode. If preferred, a SAAM presentation can be recorded in a standard "avi" movie file.